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# THE JOURNAL OF THE AMERICAN DENTAL ASSOCIATION

1934

Orthodontia—*Kelsey*
Cast Dental Gold Alloys—*Peyton*
Scientific Concept in Dentistry—*McKay*
Mandibular Movements—*MacMillan*
Immediate Denture Service—*Campbell*
Immediate Restoration—*Jaffee*
Problem of Articulator—*Hall*
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Innervation of Teeth—*Windle*
Mutilated Growth—*Todd*
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EDITORIALS

Cooperation Between Broadcasters and Dentistry
Would You Take Them Out?
Open Letter to Full Denture Specialist

COUNCIL ON DENTAL THERAPEUTICS

Accepted Dental Remedies
Premedication and Postmedication

BUREAU OF PUBLIC RELATIONS

Survey of Children of American Samoa—*Ferguson*
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LON W. MORREY, D.D.S., Chicago, Ill.
Supervisor of the Bureau of Public Relations

THE JOURNAL
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## *Original Communications*

# PLACE OF ORTHODONTIA IN THE IMPENDING WIDER HEALTH SERVICE*

By HARRY E. KELSEY, D.D.S., F.A.C.D., Baltimore, Md.

TO the layman of average intelligence, as well as to those belonging to the professions directly concerned, it must be apparent that there has been during the development of our present civilization a steady expansion in all those agencies which minister to the health and physical welfare of the public.

Coincident with this, but at a greatly accelerated pace, has been the expansion of those agencies which minister to or develop the intellectual welfare of the public. To what may be ascribed this unequal advancement (which has been most notable in the last hundred years) in the two important factors in, broadly speaking, the welfare of the individual and, of course, collectively the public?

In part at least, it would seem to be due to the fact that intellectual improvement, and the culture which was the result of it, tended to produce profound and permanent changes in the individual which equipped him for a much more desirable station in life, both socially and economically, and was, therefore, regarded as of the first importance. Its pursuit was a matter of daily concern and not to be lost sight of, except when an emergency arose.

Intellectual development was acquired by exercise of the mind, just as physical development was acquired by exercise of the body, but means for the latter were always at hand and, therefore, as is usually the case, not valued so highly; while the former could be acquired only from teachers, schools, universities and books, and at a price beyond the reach of most; but they were things with which all were familiar, because they are as old as civilization itself, or even as the human race.

They contained the sum of human knowledge, and knowledge gave position and power; and these things seem in-

*Read at the Seventy-Fifth Annual Session of the American Dental Association in conjunction with the Chicago Centennial Dental Congress, Aug. 10, 1933.

dispensable and all important to the ambitious, and a majority of human beings are ambitious, either for themselves or for their offspring.

It is true that medicine in some form or other has been practiced since the dawn of history, but it was originally shrouded in mystery and treatment consisted as much in the use of charms and incantations as in the application of drugs; though this phase of it was not entirely unknown. In fact, the armamentarium was rather large and was composed in many cases of the most disgusting materials.

Home treatment was much relied on, and the average family or individual had special or favorite medicine, even as many do today, which was used in almost all cases. In emergencies, the doctor, or whoever answered for the doctor, was called in, and often the treatment was either ineffective or fatal.

No real advance was made in medicine until people emerged from the thraldom of superstition and began to delve into the mysterious functions of the human body. The dissecting room and the microscope finally brought us out of the ignorance and superstition which characterized all early medical treatment.

This has only taken place quite recently, and it is especially true of our branch of modern health service, being due largely to the oral hygiene campaign of the last twenty years, which has at last convinced people that the care of the mouth and teeth as the gateway to the alimentary tract is essential to health and that the service offered by the dental profession is an essential part of that care. Having accepted our teaching, they now offer us a counterproposition in the perfectly logical inquiry: Where can we get this service? And so we have come to a realization of the fact, or should have come to it, that this is one more national problem and one moreover that we as a profession are not only vitally interested in, but also for the solution of which we are ethically responsible.

My own recollection of the oral hygiene movement dates back to the time when Dr. Ebersole started the campaign in which he was assisted by a number of well-known and unselfish men. Dr. Ebersole gave the remainder of the last period of his life to it and without doubt he greatly shortened his life by intense application to this campaign in conjunction with carrying on his private practice.

The profession dallied with the idea at first, but gradually it was taken up over almost the entire land. It is questionable whether many of those who seemed interested in and became champions of the cause were so interested in the public weal as was Dr. Ebersole and many of the other pioneers. Men who sacrificed as much as they did could not be accused of being mercenary in their motives, and while I have not the least intention of arraigning the profession as being so generally, I do remember hearing many discussions on this subject in which certain men went even so far as to say that the advertising dentist was taking the bread out of the mouths of their children; which was their main argument for doing away with him.

It would seem that their thought was for themselves, rather than for the public at large, and let me say that I am making no defense of the advertising quack, whom I regard with as much aversion as does anyone. It cannot be denied that the dental profession, as indeed all other professions, is a monopoly and one that has been created not by indirect but by direct legislation. Legislative bodies, in response to a demand from the budding professions, have, in the past, granted them certain powers and privileges which are denied to all others.

In no other way could the public be protected, and these legislative bodies recognized this. Business organizations have secured desired advantages, frequently, in spite of legislative opposition, but with the professions these powers and privileges were usually secured by the aid and with the assistance of legislation. Recent legislation, or rather the recent legislative aspirations of some of the societies, naturally provoke criticism by the public and press which is not in all cases complimentary.

The point is this, that while we are constantly warning the public that they should give better personal attention to the mouth and teeth and patronize dentists for reparative and preventive treatment, we are recommending legislation which will curtail the already small supply of dentists by actually limiting and even decreasing the number of students who can become practicing dentists in the future. If we are not limiting the number of students, we are at least diminishing the number of colleges, so that the output is decreased at all events. This in itself is entirely right and as it should be, considering that its object has been to eliminate those institutions which could not give a satisfactory course. The public does not understand this and is inclined to suspect our motives and view also with suspicion much of the legislative activity in which the dental societies engage from time to time and which is reported and commented on in the public press. A brief editorial which appeared in the *Baltimore Evening Sun*, March 31, 1933, seems to bear on this. It is entitled, "And Now the Dentist."

> The effort of the dentists to tighten their monopoly of the tooth pulling, straightening and filling art is making satisfactory progress at Annapolis.
>
> Their bill providing for examination by the Board of Dentistry and the granting of licenses in return for a fee went up for its third reading in the House yesterday.
>
> The lawyers, who are perhaps our most ancient profession or trade union if you prefer the word, started all this business in the present Legislature by introducing a number of bills designed to secure to them a monopoly of the practice of the law. None of the bills provided in return for the monopoly that the lawyers should relinquish their right to engage in such nonlegal activities as selling insurance and real estate. Since it was not beneath the dignity of the bar thus to seek the sanction of the State for their monopolistic ambitions, it was perhaps inevitable that their example should have been followed by the motion picture operators, the barbers and various other occupational groups. Surely, the old saying that every profession is a conspiracy against the laity is being demonstrated in the current session at Annapolis.

The dental bill referred to in this editorial is one which was introduced by the Maryland State Dental Association and which provided numerous unquestionably beneficial changes in the present law. Probably the one to which exception was taken in the editorial just quoted was that which referred to further restrictions on the advertising dentists.

To show my thorough approval of the law, I need only state that I was a member of the committee that prepared it and presented it to the state association for approval before its being presented at Annapolis. I have felt that our action would be misinterpreted by the public as it has often been in the past. We are not really trying to curtail the number of dentists or the amount of dental service which can be given, although it might be suspected by the uninformed public that we were interfering with the price at which people have been able to procure dental service heretofore. Broadly speaking, this legislation is designed only to put a stop to the false and misleading advertisements which are so often indulged in by men who are themselves graduates and licensed practitioners, and who can continue to practice under the new conditions, just as others who are

ethically minded do; but the public generally does not understand this and believe our activities are directed toward tightening our monopoly and improving our income by making it impossible for them to receive a service to which they have become accustomed and which is advertised to them as being just as good and far cheaper. In fact, to a very large part of the general public the advertiser appears to be the outstanding man. Often, he is the only one they have heard of, and the fact that he is so enterprising as to advertise his wares seems to them, with their lack of ethical education, to stamp him as being at the forefront of his profession.

They do not know, although it is well known to us, that the advertiser charges just as much for his services as he can get, and that they often pay more to him than they would to an ethical practitioner and probably receive very inferior service.

Our campaign of education, therefore, seems to have brought us to an impasse. What are we going to do about it? If we do not do something, it will be done for us. At this point, it might be well to review the development of universal educational service and note whether there are any phases of it which are applicable to a similar universal health service.

In a paper read before the New York Society of Orthodontists in March, 1932, I[1] referred to this subject.

> The country has been confronted with a similar problem in another matter and we speak with pride today of its solution. I refer to universal education. There has always been educational service as well as health service for those who could pay for it, but up to about 100 years ago there was no educational service supplied to those who could not pay for it. About that time the more progressive element in society believed that all individuals should have at least some education; that being born free and equal did not enable an individual to win out or even hold his own in the game of life unless he had some of the environmental advantages which were needed to enable him to compete with other individuals more fortunately born, so far as this world's goods are concerned. In other words, if he had no education he could not compete in those pursuits where it was essential. Therefore, a very little free school was provided. The results must have been convincing because from that time until the present there has been a steady development of the free school system, passing through the stage where all might have a reasonable education to the state where all were required to attend the free schools if they did not go to private ones, and finally to the present state where not merely the abstract subjects are taught but where many trades can be partially learned. In other words, compulsory education has been achieved. This is paid for out of the public funds and no child who goes to the public school, nor his parents feel that they are in any sense accepting charity. This development of the intellectual side of the individual has been done in the belief that he should have a competing opportunity and also because it was believed that it made for better citizenship; that the best citizen was the one who had at least a reasonable education. If this be true, how much more important is the physical well-being of the individual; for if the physical well-being is seriously impaired, the individual is not only directly handicapped as a citizen but he is not even able to take full advantage of the educational opportunities which are offered. This seems logical to me and I believe that it is beginning to seem logical to the general public. We have educated the public to the need for health service in our own specialty and the same thing has been going on in all branches of medicine. Is it surprising that they are beginning to inquire very anxiously where they can get this beneficial service? My feeling is that we have about arrived at the time where the politician will see strong possibilities in this question. He may represent to his constituents that this thing which the professional man enjoys is a monopoly, and can we deny that it is a monopoly? No individual may practice or offer health service who has not conformed to certain rather long and strenu-

1. Kelsey, H. E.: Public Clinic as Measure of Cost and Value of Universal Health Service, Internat. J. Orthodontia, 19:424 (April) 1933.

ous requirements and has passed examinations which certify to his ability. If anyone else undertakes to offer any kind of health service he is liable to severe penalties.

The politicians and the people will undoubtedly, sooner or later, realize that this monopoly has been granted through legislatures which award to colleges charters which give them the right to grant diplomas to those individuals complying with the specified requirements. With this diploma as a prerequisite, the graduate, and he only, is then eligible to take an examination for a license to practice and if he successfully passes it, he then joins the ranks of those who are permitted to offer their services to the public. The medical and dental professions have steadily elevated the standard for admission to their ranks and have given fully as much attention to the ethical as to the practical side of the matter. Our ideals are of the highest and the best element of the profession endeavors to live up to them, but we are working under a system which was inaugurated before the need for universal health service was recognized. For in the past little, if any, health service was given or advocated until the patient was ill, and under those conditions, of course, the demand for service was not universal; but now that the profession first and the laity secondly has realized the need for prevention and hygiene as well as reparative service, something will have to be done, and I am certain that something will be done, within a few years, to supply them.

The people will be informed, if they are not already, that they themselves have granted the power to the various professions to practice them exclusively and it will occur to them eventually that they can also make other regulations concerning the situation. It behooves the profession, therefore, both in its own interest and in the interest of the public generally to have a hand in whatever changes may be brought about. That there will be changes there can be no doubt, and that they will be unwise if not guided by the conscientious effort of the best element in the profession also cannot be doubted.

Dental service and especially orthodontic service cannot be given cheaply and this has been one of the difficulties in establishing dental clinics in comparison with clinics for general medicine and other special branches of medicine. Compare, for instance, the time required for the correction of a case of malocclusion with that required for a tonsillectomy. All the more, therefore, is it a matter which can only be adequately taken care of by service supplied by the community or the state.

This last statement expresses a conviction which I have held for sometime past, but which has been shaken recently by the classic presentation by William J. Gies,[2] of Columbia University. Here we have a man who, though a layman, exhibits an enthusiasm which would do credit to the best members of our profession. His object is clearly, first, the welfare of the general public, and, secondly, the improving of the standards and ideals of health service. It is difficult, if not impossible, for one in the profession to get the same point of view as that of a layman who has become interested in the subject and who has, as in this instance, had a vast amount of experience over a number of years in activities which have necessitated his making a complete and thorough analysis of this whole subject. The dental profession should, and I believe does, accord Dr. Gies its grateful acknowledgment for the splendid service he has rendered it.

In a supplement to his report, he offers a substitute for state medicine. He says, "This substitute would affect dentistry as one of the separately organized cooperating health service professions concerned."

I will quote only paragraph C, referring you to his report for a fuller acquaintance with his careful analysis of the subject.

State medicine would lose its appeal as a practical solution of the present economic difficulties if the organized health service professions in effective cooperation should meet the situation in harmony with their humanitarian purposes and in due recognition of existing economics in equality. This they can do by systematically organizing and maintaining institutions or groups to provide excellent preventive and clinical health service, at moderate fees, specifically for patients having low

2. Gies, W. J.: Status of Dentistry, J. D. Res., 12:945 (Dec.) 1932.

incomes. Such institutions or groups should be established under professional auspices only; if, where, when and as community needs would determine. Public spirited laymen would certainly cooperate in founding and maintaining these health service agencies.

Now if public spirited laymen *would* cooperate to a sufficient degree to provide universal health service agencies, and if the professions, at the same time, did their part, we would hear no more of state dentistry.

When I read Dr. Gies' enthusiastic report, and Colonel Messner's thoughtful paper,[3] I feel that they will do so and that the professions will correspondingly cooperate, but when I think of the difficulty encountered by all agencies created as beneficent institutions, but which depend on private endowments for support and maintenance, I am again thrown into doubt. One thing is sure, universal health service there will be, and in either case it behooves the professions concerned to take a prominent and influential part in its inception and organization. It will be much easier if the proposal for universal health service comes from the professions rather than from the public.

As Dr. Gies very truly remarks, "If the professions concerned do not provide a wider health service the public in desperation will cast about for means to provide it themselves." The politician will inevitably get into the game and state health service will undoubtedly be the result. If state health service is launched under the guidance and supervision of the professions, it may be done with no more, and probably less, of the pernicious political influence than has in varying degrees characterized state education. Had it not been for the long period of business and financial depression through which we have been passing, this question of universal health service would have been in the first experimental stages. As we emerge from the depression, as we surely will, its pressing nature as a public need will again bring it rapidly to the front, and the profession should be prepared, at that time, to offer a rational plan whereby there can be instituted the beginnings of such a service, which may grow, in time, to cover the field as thoroughly as does universal education today.

The enormous expense of universal education has come in for considerable criticism, and will prove to be one of the deterring influences delaying universal health service; and although I may be accused of taking a reactionary stand, I believe that enough money is wasted each year in attempting to educate, beyond a reasonable point, those who by nature can never assimilate such knowledge to practically pay for necessary health service. This naturally brings us back to a consideration of the cost of education as compared with the cost of health service. A few figures relating to the cost of free education may not be out of place. To quote again from the paper[1] before referred to:

> A rough estimate of the time required for dental treatment, including orthodontia, for the average child is fifteen hours a year. Add to this all the forms of treatment the child might require and it will amount to probably not over twenty-five hours a year. Now if that is actually the case and yet the child is provided with 1,200 or more hours of service per year in the educational field, does it not seem absurd that he should not have the twenty or thirty hours required for the care of the body? Much of the plant needed for this service already exists in the elaborate school buildings, and equipment, which in Baltimore (one city with which I am familiar) represents an outlay per pupil of $377.54. These buildings can provide the required space, without further expense, except for some special equipment for giving practically all treatment, except that for which the patient must go to the hospital, or remain in bed at home.

3. Messner, C. T.: Dentistry in Public Health, J.A.D.A., 17:2313 (Dec.) 1930.

No doubt there will be much objection in some quarters to supplying free medical and dental service, but I am told there was just the same objection raised to the supplying of free educational service. My feeling is that some of the opposition that is expressed by dentists to universal free health service is based upon fear. In connection with that, I wish to say that it seems to me that universal service, supplied by the State, would be as great a boon to the professions as it would to the laity. All men of outstanding ability would continue to attract to themselves a clientele who would prefer to go to them, rather than to the more promiscuous public clinics, because they are fortunate enough to have the means to pay for the more exclusive service, so that, the private practitioner would be analogous to the teacher in the private school of today, and he would be relieved from the great burden of supplying much free service that ought, by right, to be paid for by the State.

Those men who have ability, but do not succeed well today, would be much better off if employed by the State. Their income would be much more secure and would be even larger. The opportunity for research, on the part of both the public clinic practitioner and the private practitioner, would be immensely enhanced, and the private practitioner could with a good conscience refer those people who sought his services but could not pay the fees he felt justified in charging, to the service supplied by the State, which should be just as thorough and painstaking as his own.

It is believed by many that the teaching supplied by the public schools of today is quite equal to and in many instances superior to that supplied by private schools; yet, in spite of this, there is now and probably always will be a demand for the private school, just as there will be if free health service is inaugurated, a demand for the private practitioner.

The danger, of course, in establishing free health service lies in the possibility of producing a large number of ill-equipped practitioners and here again it is up to the profession to see that the large number of dentists which will be required when and if this thing comes to pass measures up to the standards which have already been made.

Nevertheless, if the welfare of the public demands free health service, and if this should completely extinguish the present private health service, we must believe, if we are honest in our statements, that it would be for the general good, even if worse for us. In other words, we are practicing a profession which has been established in answer to a public need. We have not created a fictitious demand for something which we have to supply. The need or demand has been there all the time, and in spite of preventive measures, will be there for a long time to come.

To meet this need adequately, the number of our profession will have to be greatly augmented; that is, to meet it in a universal way, and this may be the next great problem which we will have to respond to.

Granting, then, that universal health service is realized, whether it be through the intervention of the state or through endowments by that wealthy portion of the population who may become sufficiently interested to provide the means for its establishment, we are brought to the final proposition indicated in the title: "The Place Orthodontia Will Occupy in It." As I have said, "Dental service, and especially orthodontic service as it has been conducted in the past, cannot be given as cheaply as can some other forms of health service, but under more ideal conditions where all children are under observation from infancy so many malocclusions can be prevented as to greatly reduce the amount of time and work which would have to be given to this particular phase of the service." A thorough study of the writings of Dr. Willett[4]

4. Willett, R. C.: Children's Dentistry from Orthodontist's Point of View, Internat. J. Orthodontia, 17:552 (June) 1931. Improved Operative Technique for Deciduous Molars, D. Items Int., 53:489 (July) 1931. Cooperation of Family Dentist in Mouth Hygiene Movement, J.A.D.A., 16:2151 (Nov.) 1929. Intercepting of Certain Types of Malocclusion, ibid., 16:389 (March) 1929. Radical Departures from Theories and Methods Pertaining to Children's Dentistry, ibid., 19:1085 (July) 1932.

will convince anyone that if all children were brought under the care of men who understood as he does not only the importance but also the technic of heading off approaching malocclusion, the burden of the orthodontist would be greatly lessened. Dr. Willett has called this work in the numerous papers which he has written on the subject, "The interception of malocclusion" and I would advise anyone at all interested in this subject to read carefully everything he has written on it; for although there are others who have recently and at an earlier time written excellent articles on this subject, there is no one that I know of who has treated it so exhaustively and followed up the technic of the principles upon which it is based as has Dr. Willett.

His theories have all been put into practice, and he has demonstrated the feasibility of everything which he proposes. Moreover, he has conducted most of his experimental work on a class of children who are the least promising as patients, believing that if he could accomplish his results in these cases, there would be no excuse for others more fortunately situated not securing similar benefits.

Fundamentally, he believes that if the teeth and jaws are maintained in a normal functional activity, development will take place along normal lines. While this theory has been held by many men, few, if any, have carried the technic out so thoroughly as he for bringing about and maintaining this condition. There can be no doubt that children receiving such service as this, in conjunction with all other health service, which of course, is just as important, would exhibit far fewer cases of malocclusion as they grow up, but none of us believe that prevention can be carried out 100 per cent; nor do I mean to imply that Dr. Willett does not recognize that there are other varied and often complex factors in the etiology of malocclusion.

There will still be malocclusion in spite of universal health service and our best efforts, but it is reasonable to suppose that the amount of malocclusion may be greatly reduced as well as the complexity of many of the cases, and therefore, there will be a diminution in the amount of time required for their treatment. The other possible factor in lessening the burden of orthodontic treatment is the increase in our knowledge of the etiology of malocclusion, and, of course, with this, the possibility of a more exact diagnosis than we have hitherto been able to make. Thus, we may be able to determine accurately the individual developmental possibilities of a case at the time we are confronted with it for treatment, saving thereby a great waste of time and effort.

During the last ten years, a great number of diagnostic methods have been presented to the profession, from which we have hoped much, but so far not one of them has made it possible for us to diagnose a case with such certainty and accuracy that we feel justified in pursuing a radical course at the outset. It is our hope that this goal will be reached in time. It would be ideal if we could say of an individual case: This child's dental arches and supporting bony structures will never develop sufficiently to contain the thirty-two teeth which have been provided for it and, therefore, at the most suitable age, one or more of the premolar teeth must be removed; this procedure to be followed, of course, by adequate orthodontic treatment; but we have not yet travelled so far as this along the diagnostic road.

In a paper read before the Maryland State Dental Association several years

ago, I[5] expressed my convictions with regard to the extraction of teeth as a procedure in orthodontic treatment, and in spite of the vast amount of study by many able men which has been given to the subject of etiology and diagnosis since that time, I find myself unable to change my views with regard to all those cases which have still before them the strong possibility of developmental changes, cases in which there is at least a portion of the temporary dentition still present, and cases even a year or two after the deciduous teeth have been lost and their successors have taken their places. My opinion at that time was, and it still is, that only after an honest effort had been made to reduce a case of malocclusion and bring about a normal relation of the teeth to each other, and all means to that end had been exhausted and proved a failure, was it justifiable to resort to extraction. The reason for this is that of two cases presenting an identical malocclusion, one will yield quite readily to orthodontic treatment and a normal occlusion of the teeth and relationship of one dental arch to the other can be secured, while the other, in spite of our best efforts, will turn out a failure. We must still give the benefit of the doubt to both cases, and only resort to extraction when we have demonstrated experimentally that sufficient development cannot be secured to make room for all of the thirty-two teeth in the dental arches, or that a mesiodistal malrelation of the dental arches cannot be corrected along ideal lines. After the sixteenth year, the experienced orthodontist should be able to determine, in order not to waste his patient's and his own time, whether treatment along ideal lines may be successful, and if he decides that it will not, he should then have the courage to adopt a compromise treatment, removing a tooth or teeth if necessary.

At the inception of a universal health service, there would undoubtedly be a vast number of such cases which would be presented for treatment and decisions based upon wide experience would greatly curtail the time and energy needed to meet the situation.

The danger in ever advocating extraction as an orthodontic measure is that so many general practitioners are apt to accept such advocacy as a justification for extraction in all cases which come under their observation.

On the contrary, it is not a justification, and no one who has not had a broad orthodontic experience has any right to extract a tooth as an orthodontic measure without securing the opinion of someone who has; for if he pursues such a practice, he will inevitably do immeasurable harm; first, because his lack of experience will not enable him to differentiate between those cases which really call for extraction and those which are capable of being restored by good orthodontic treatment to normal occlusion, and, secondly, because where extraction is indicated, it must still, with rare exceptions, be accompanied by intelligent orthodontic treatment. To merely extract, without being able to give the indicated orthodontic treatment also, will usually only aggravate the malocclusion, except, of course, in some very rare cases, the discussion of which is out of place here. In the wider health service, then, which I believe to be impending, there is undoubtedly a need and a place for orthodontia, but it must for reasons already stated be under the supervivsion of the orthodontist. His work and the work of

5. Kelsey, H. E.: Consideration of Fundamental Principles Underlying Classification and Diagnosis, and Some Factors or Conditions Which If Observed in Time May by Proper Advice Avert Impending Malocclusion or Insure Treatment at Most Favorable Age. (Unpublished data.)

the general practitioner will meet in the field of prevention and interception. The intelligent cooperation of all the specialties with the general practice of dentistry can, through painstaking and tireless effort, meet in a practical manner the dental phases of a universal health service, and I believe at a cost which will not be out of proportion to the advantages which it will bestow.

Of course, the figures here given as to the cost of education apply only to that portion of the population who are in the free public schools. It will be argued that free health service would involve the entire population and would, therefore, be in demand by four or five times as many individuals; but this is not so serious as it seems at first when it is considered that each of these individuals does not have all the various ills nor does each one go through the same almost continuous régime as do pupils in the schools.

Furthermore, the number who would apply for free health service would be greatly diminished by that large class who would still prefer to have the more exclusive private service and also by that class, that fairly large and fortunate class I may say, who remain well most or all of the time. That the public generally is becoming interested in orthodontia is manifest by the rapidly increasing number of applications for such service in the various clinics and at the college infirmaries. I am told by those in charge of the orthodontic department in some of the colleges that the applications far outrun the capacity of the department to take care of the cases and there is an increasingly long waiting list. This has also been my experience in the orthodontic division of the dental clinic at the Johns Hopkins Hospital. While this demand is due partly to the unfortunate financial situation of the present time, it reflects in a general way the appreciation which the public has acquired for orthodontic service. It is also significant that many people of small means deny themselves much in order to give this treatment to their children. The need is obvious, and the results have been, in a general way (at least in the eyes of the laity), sufficiently successful to excite this constantly increasing demand for it.

To those associated with any public clinic or college infirmary, it is actually distressing to note the keen competition which exists among patrons to secure for their children the benefit of this service. It seems that almost all people, if not the entire public, have become aware of the need for orthodontic treatment where malocclusion exists and have learned that there is such a service, which can be had if they can pay for it, and sometimes may be had in clinics at a more moderate charge. It is also significant that there are often brought to the orthodontist for treatment children whose mouths have been seriously neglected in other respects, doubtless because the need for orthodontic treatment was so much more obvious to the parents than was the need for reparative work such as fillings, for which they often wait until the child is suffering, a most unfortunate phase of the situation.

In a paper read before the meeting of the American Society of Orthodontists at Toronto, in May, 1932, Abram Hoffman[6] referred to this subject. I quote:

> The first step has been to discover the dental health need of the public from the viewpoint of the layman. Five hundred questionnaire forms were sent to persons residing in thirty-one states of the United States and eight provinces of Canada. These persons represented various vocations, and community interests. Their replies give interesting indica-

6. Hoffman, Abram: What May Be Considered Rational Methods in Orthodontic Therapy, Internat. J. Orthodontia, 19:233 (March) 1933.

tions of the conception of the health needs for which the dentist should render service (and please note this) that third in their list of needs is treatment of irregularities of the teeth. These laymen were also asked to indicate which dental health need, in their opinion, the dental profession fails to meet adequately, and here in the fourth position we find the treatment of irregularities of the teeth.

It is evident, then, that orthodontia will necessarily have an important place in the dental division of universal health service, when that greatly to be desired boon to humanity has been realized, and it is my conviction that as the country returns to normality in a financial way, the public will energetically support some method for bringing it about. If the method be a good one and under the supervision of the professions concerned, so much the better; but if they, the professions, have nothing to offer, or rather if they do not take the initiative, it will undoubtedly be taken by someone else, possibly by those of political aspirations, who rarely fail to recognize an opportunity.

It is not reasonable to suppose that universal health service can be established as an entirely new department of government, supported by entirely new taxation.

As stated before, we have probably gone too far with free education, and some of the money that we are spending in that department may very well take care of a new department of health service.

I often think of what a very intelligent mother of three or four children who were patients of mine said to me when speaking of the difficulty of having children keep all of the multifarious engagements necessary to their education, and of visits to all of the various doctors who looked after their health. Her words were, "I am determined that my children shall grow up with healthy bodies even if they do not know a thing"; and she was one of the most cooperative parents with whom I have dealt in a long experience.

Those engagements which concerned the health of her children she regarded as of first importance, although she by no means underestimated the value of education, and these children all went to the best private schools and got their languages from their governess and tutor in addition.

This woman's attitude toward her children, if adopted by the government toward individuals, might well be termed governmental paternalism, something which in a broad sense is as objectionable to me as it can possibly be to anyone. Nevertheless, in matters of health, it is already conceded by practically everyone that the government should interfere with the personal liberty of the individual in order to protect the welfare of the public generally, as witness the governmental supervision of those individuals who have contracted some contagious disease.

Such supervision does not yet extend to a great many communicable diseases which are in fact today much more serious than is smallpox (which is under governmental supervision), because, while they may not be so deadly, they are yet doing vastly more harm than smallpox, simply because they are not under supervision. The social, or so-called social, diseases stand, of course, at the head of any such list.

I have a sympathetic feeling for the person who objects to being forced to submit to vaccination for smallpox, notwithstanding the fact that I believe that it is perfectly right and proper that he should submit to it.

I resent and always will resent governmental interference with my behavior as an individual which in no way affects the welfare of those around me. There are

people who believe that it is quite justifiable for the government to interfere with our personal behavior even though that behavior only endangers our own personal welfare and carries no menace to those about us.

We are only just recovering from one such experiment. Universal free health service could not be objected to by anyone, save on economic grounds. Compulsory health service will undoubtedly meet with very serious opposition, as it always has, even when exercised purely as a protection to the public.

Nevertheless, after a thoughtful analysis of the subject, to me at least the conviction is inescapable that it would have benefits for the race as a whole (benefits which are now enjoyed by our domestic animals only) entirely outweighing its objectionable features.

833 Park Avenue.

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# FLEXURE FATIGUE STUDIES OF CAST DENTAL GOLD ALLOYS*

By FLOYD A. PEYTON, D.Sc., Ann Arbor, Mich.

SINCE there are such varied demands on the structures used in reconstruction in dentistry, the development of suitable alloys is a complicated problem. The extreme limitations on the size of the structures, the severe stresses that are applied and the varied chemical problems involved in a consideration of the saliva, products of decomposition and food products furnish a variety of problems in dental alloy construction rarely equaled in any other branch of metallurgy.

In some instances, structures are required which are fixed firmly in place by cements, with no flexure and no movement of the structure. In such cases, the matter of strength is less important than is some others. A certain degree of strength with a high degree of ductility, which will permit the finishing of a tight margin, are most desirable properties. In other cases, if the piece is removable and therefore subjected to the hazard of fracture from falling and to a high degree of stress in the mouth, it cannot be malleable or ductile to the same degree as some metals and alloys used for other dental reconstruction purposes. In such cases, the highest possible degree of strength with a high flexure fatigue limit are the properties most desirable. In certain other cases in the mouth, if there is not proper care, structures which are used are subjected to processes of the most extreme discoloration and disintegration by saliva, food and products of fermentation.

These are only a few examples of many which could be mentioned to show the extremely intricate nature of the production of dental alloys that meet all the needs of dental practice. In no case have the uncombined metals been suitable for this purpose. Gold, platinum and palladium are the only metals

*From a portion of a dissertation submitted to the Graduate School of the University of Michigan, in partial fulfilment of the requirements for the degree of doctor of science.

which would meet the needs of dental practice from the standpoint of discoloration and disintegration and would be ductile and malleable enough to be worked into form and to be made into tight fillings. None of them would be strong enough to resist sufficiently the stresses to which they would be subjected. Several other metals would meet the needs of dentistry from the standpoint of workability, but no others have been found which have a high enough resistance to discoloration and disintegration in the mouth. Up to the present, it has been considered necessary, therefore, to develop a large number of alloys to meet the different needs of dental practice and, in all cases, it has been necessary to rely on a high enough content of the noble metals, namely, gold, platinum and palladium, to prevent discoloration and disintegration.

In the earlier periods of dental practice, coin gold, 90 per cent gold and 10 per cent copper, constituted the principal material for the construction of dental appliances, and dental practice was limited very greatly on account of the few desirable properties possessed by this material. It was not only objectionable from the standpoint of discoloration, but it was also neither hard enough nor tough enough to resist the stresses to which appliances that are now made are subjected.

This is the only important instance in dentistry wherein the binary system of alloys has played any part in the development of dental practice. As physical metallurgy has developed during recent years, the ternary alloys, namely, gold, copper, and silver, have been developed[1] and dental practice has, as a result, been extended just in proportion as these ternary alloys possessed the properties required in dental appliances. During very recent years, through the

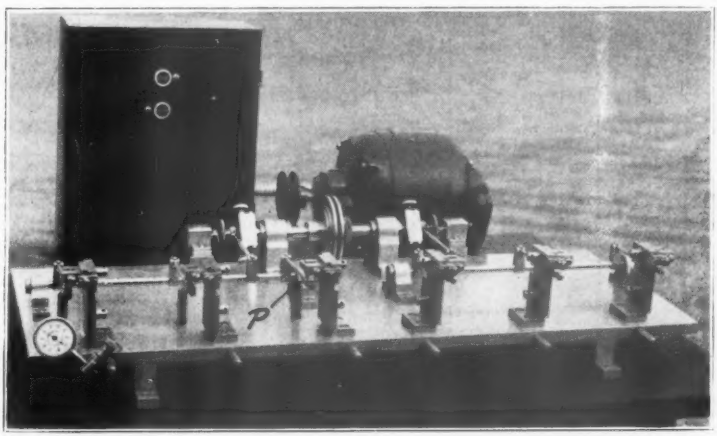


Fig. 1.—Flexure fatigue machine designed for gold alloys.

1. Sterner-Rainer, L.: Edelmetallegierungen, Berlin: Herman Meusser, 1930. Janecke, E.: Metallurgie, 8: 567, 1911.

work of Wise, Crowell, and Eash,[2] who have contributed very materially to the knowledge of the development of the commonly accepted physical properties of these alloys, there is now available information on two or three quaternary systems involving gold, copper, silver and either platinum or palladium. The authors mentioned have also shown, through some excellent studies, that the precious metals in the binary, ternary, quaternary and quinary systems are all subject to heat treatment, and they have also given some physical property values for many of these alloys. Probably the most important data contained in the work of these authors are those which show that gold, copper and silver, with gold in excess of 60 per cent by weight to prevent discoloration and disintegration, form the basis of the more favorable, though somewhat more complicated, quaternary and quinary alloys. These workers as well as all others some of whose names will follow, have done nothing to show the flexure fatigue values of the alloys with which they have worked and, as a result, the application of the alloys on which work has been done to the needs of denture construction, where flexure fatigue is such a necessary property, is very limited.

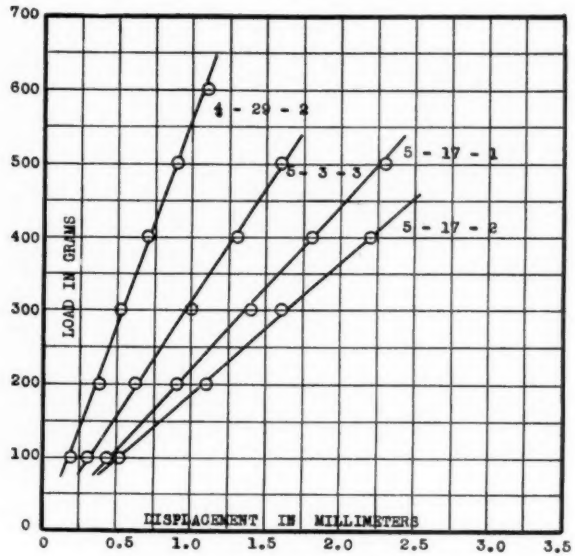


Fig. 2.—Relation of load to displacement.

The work of Coleman[3] has shown the composition and physical properties representative of commercial alloys, including (1) wrought wires, (2) wrought band material, (3) casting alloys for clasps, (4) casting alloys for crowns and

2. Wise, E. M.; Crowell, W. S., and Eash, J. T.: Preprint, A. I. M. E., February, 1932. Wise, E. M., and Eash, J. T.: Inst. of Metals Div., A. I. M. E., February, 1933.

3. Coleman, R. L.: U. S. Bur. Stand. J. Res., Paper No. 32, 1: 867, 1928.

inlays and (5) solders designed for different alloys. In general, these alloys, like those mentioned by Wise, Crowell and Eash,[2] are made up of four major constituents except where part of the platinum has been replaced by palladium to give a five component alloy. A large number of these alloys also contain certain smaller percentages of one or all of the metals, nickel, zinc, iridium and tin. It has been pointed out that a small percentage of zinc is usually added to produce soundness of the alloy, while a larger percentage is added in the gold solders to lower the melting point. Many of the inlay materials listed by Coleman are seen to be three component alloys. A study of the physical properties shows that for the various casting alloys, the ultimate tensile strength range varies between approximately 17,000 pounds per square inch to 100,000 pounds per square inch, while wrought alloys show tensile strengths of approximately 100,000 pounds per square inch to 175,000 pounds per square inch, depending apparently on the intended use, composition and heat treatment of the alloy. The other physical properties vary accordingly.

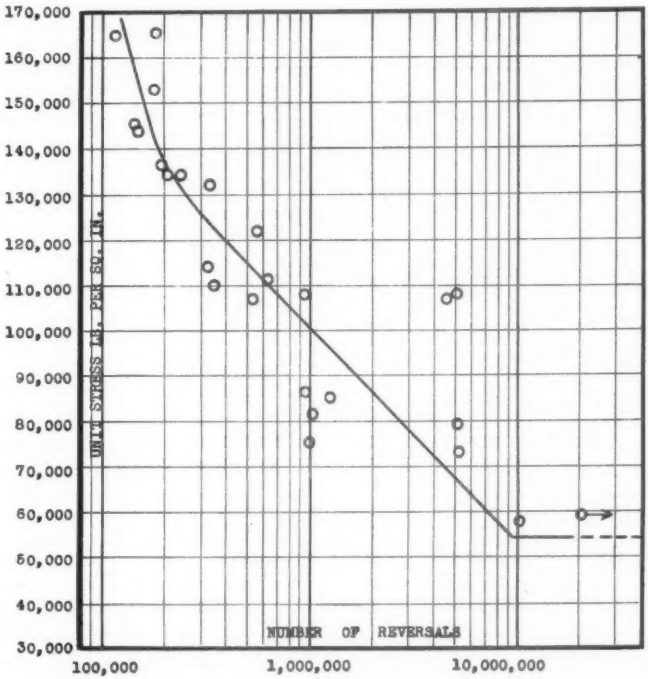


Fig. 3.—Relation of stress to reversals, alloy No. 1.

These studies of Wise, Crowell, Eash and Coleman summarize quite completely the development of the general properties associated with dental alloys as a whole.

Many valuable specific studies have also been made on the development of some one system or set of properties,[4] but these and numerous others have been more or less completely reviewed in the works of Wise and his co-workers.

### FLEXURE FATIGUE TESTS ON CAST GOLD ALLOYS

Cast clasps, arches, bars and a variety of other assembled or one-piece castings are among the appliances used in corrective dentistry. All of these structures are subject to more or less flexure when in use. On of the most significant features of these appliances is perhaps the fact that they are used in the cast condition, without any further mechanical treatment. None of the processes of working into shape, such as rolling, drawing or hammering, are used on these cast structures, except the small amount of cold working that accompanies the polishing of the finished appliance. In general, therefore, their physical properties are similar to the physical properties associated with other cast metals.

By elimination of the processes of working into shape, a number of interesting restrictions are placed on the operator and on the materials used. First, the operator who wishes to employ a cast appliance must be able to reproduce with a high degree of accuracy the shape and dimensions needed in the constructed part, i.e., the structure must be cast to dimensions, within fine limits. No machining to dimensions is practicable. In general, the removal of possible slight excess material is the only per-

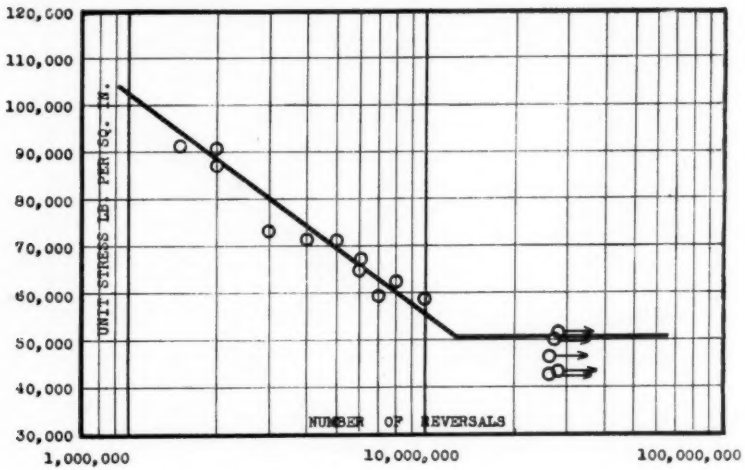


Fig. 4.—Relation of stress to reversals, alloy No. 1.

4. Kurnakow, N.; Zemczuzny, S., and Zasedatelev, M.: J. Inst. Metals, 15: 305, 1916. Stockdale, D.: J. Inst. Metals, 45: 127, 1931. Nowack, L.: Z. Metallkunde, 22:94, 1930. Haughton, J. L., and Payne, R. J. M.: Inst. Met., Preprint No. 571, 1931. Carter, F. E.: A. I. M. E., Tech. Pub. No. 86, 1928. Ohshima, M., and Sachs G.: Z. Physik, 63: 210, 1930.

missible correction that may be made on dental castings.

Secondly, the material itself is required to possess properties of somewhat rigid nature. As an aid to casting, these dental alloys should have as low a melting point as possible; yet, in addition, as has been pointed out in the introduction, they must possess superior physical properties as well as resistance to discoloration and disintegration.

Because of the flexure of the cast structure under continued use, breakage often occurs. This failure may not be due necessarily to defective material or defective workmanship. It may be caused by the continued deflection of the appliance, introducing stresses sufficient to produce fracture in the portion receiving the greatest stress. This would indicate incorrect design in the appliance. When fracture occurs in one section, greater stress is introduced into the remaining material. Because of this increase in stress, the fracture progresses across the structure until rupture is complete. This has become generally known as the fatigue of the metal. Fatigue of metals has been defined by the Research Committee of the American Society for Testing Materials[5] as "the phenomenon of the progressive fracture of a metal by means of a crack which spreads under repeated cycles of stress." A more precise term to express this type of failure would be "progressive fracture," as has been pointed out by this committee. The endurance limit has likewise been defined by the committee as the limiting stress that may be introduced without fracture by an indefinite number of cycles of stress. This states that below a certain limiting unit stress, fracture may not be expected to occur even with an indefinite number of cycles.

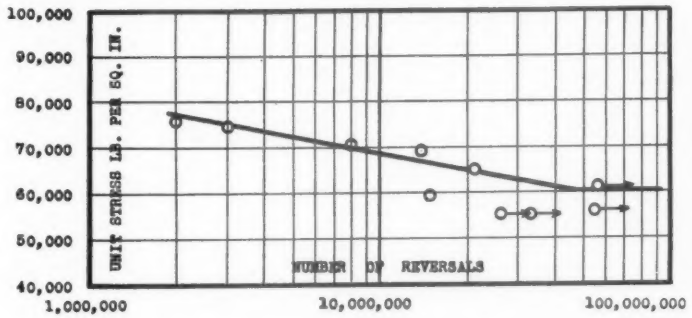


Fig. 5.—Relation of stress to reversals, alloy No. 2.

The term "endurance limit" has been used as synonymous with fatigue limit.

The object of this study has been to develop a flexure machine suitable to test the fatigue limit of small samples of gold alloys, to determine some of the fatigue properties of the cast alloys and to study the relation of flexure fatigue to other commonly observed physical properties. As has already been pointed out, apparently sound castings will sometimes fail when subjected to long continued use.

5. Report of Research Committee on Fatigue of Metals, Proc. A. S. T. M., 30: 260, 1930.

One of the purposes of this study, therefore, was to investigate and point out, if possible, some of the conditions necessary to increase the life of cast structures.

From studies on other metals, both ferrous and nonferrous, investigations have been made into the relation existing between fatigue and other physical properties. A summary of the correlations made between these properties has been given by Townsend,[6] who reports that, for all metals, no direct relation exists between the endurance limit and any of the other physical properties, most consistent correlation with fatigue limits of all the properties studied. This conclusion has been supplemented by investigations of other men. Kommers[7] has reported similar results on the static and fatigue properties of brass. The conclusion from his work has been that "neither the proportional elastic limit, Johnson's elastic limit, and proof stress, nor the Rockwell hardness showed a consistent relation to the endurance limit, and therefore these results cannot be used as criteria of fatigue strength." He states further that "even the tensile

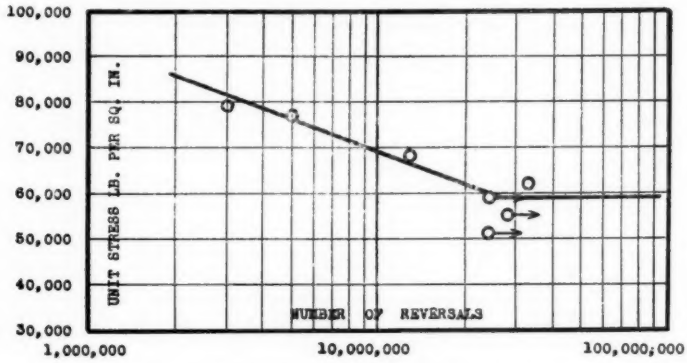


Fig. 6.—Relation of stress to reversals, alloy No. 3.

although no reference is given to data on the precious metals or their alloys. Correlation of certain physical properties of some metals does bear a somewhat consistent relation to the fatigue limit. This correlation is best established in the ferrous metals, although even here the relations are only approximate within limits. Such properties as tensile strength, Rockwell and Brinell hardness numbers, modulus of rupture and the electrical resistance have given the strength cannot be relied upon as a definite criterion of fatigue strength, the endurance ratios varying from 30 to 50 per cent." Thus, these two and other investigators[8] have reported that no general correlations exist for endurance limit and physical properties.

6. Townsend, J. R.: Proc. A. S. T. M., 30: 270, 1930.

7. Kommers, J. B.: Preprint No. 43, A. S. T. M., 1931.

8. Moore, R. R.: Proc. A. S. T. M., 23: 106, 1923. McAdam, D. J., Jr.: Proc. A. S. T. M., 23: 23, 56, 1923. Townsend, J. R., and Grenall, C. H.: Proc. A. S. T. M., 29: 353, 1929.

*Methods for Making Flexure Tests.*—At least two books[9] and a great amount of periodical literature have been written on the fatigue of metals. One of the most complete summaries on the present-day knowledge of fatigue of metals has been given in a report of the Research Committee on the Fatigue of Metals, for the American Society for Testing Materials.[5] This report also includes a complete bibliography on the fundamentally important investigations into fatigue and related properties. No tests have been reported in the literature on the fatigue of cast dental alloys. Only one brief report has been given for the flexure of any gold alloys, and this was made by Coleman on the static flexure tests of wrought gold wires.[8] Since the properties of wrought wires are rather widely different from the properties of cast metals, the report by Coleman has but limited application in this work.

Because of the nature of this study, a number of interesting problems have arisen in connection with the design of both a suitable testing machine for these cast gold alloys and suitable samples that might give comparable results of flexure fatigue values. For two reasons, it was desirable to use small samples in this fatigue study of cast alloys: (1) to keep the size of the test piece within comparable limits of the size of clasps or bars used in the appliances, and (2) to minimize the cost of samples by employing the smallest possible dimensions that would still produce consistent and comparable results. Peterson has summarized the effect of specimen size on fatigue results.[10] His conclusion has been that "no appreciable size effect was found in fatigue tests of carbon steels for sizes 0.050 inch diameter to 2 inches diameter." He did find that for porous materials such as cast iron and weld metal, it was inadvisable to use small specimens, as a lower endurance limit was obtained with

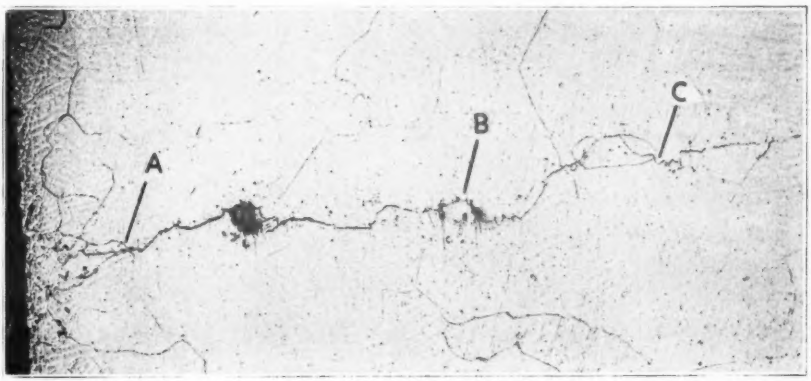


Fig. 7.—Course of fatigue crack in gold alloy. (Reduced about one-third from magnification ×150.)

9. Moore, H. F., and Kommers, J. B.: Fatigue of Metals, Ed. 1, New York: McGraw-Hill Book Co., Inc., 1927. Gough, H. J.: Fatigue of Metals, New York: D. Van Nostrand and Co., 1924.

10. Peterson, R. E.: A. S. S. T., Preprint No. 2, 1930.

a considerable "scattering" of test data.

Most present-day fatigue studies have been made by using a rotating beam type of machine with a constant load. Peterson[10] has described a flexure machine of this type suitable to test specimens of small dimensions and of the correct magnitude for this study of gold alloys. Because of the fact that cast dental structures are seldom, if ever, round, and because they have varying thicknesses that cover a range of from a square cross-section to approximately thin sheets, it was considered that some other type of flexure machine than the one described would be more adapted to this study. Furthermore, dental castings are always used as stationary beams rather than as rotating cantilever beams; which seemed to add to the justification for the use of a fatigue machine producing constant deflection of a rectangular cross-section fixed cantilever.

*Cast Gold Alloy Fatigue Specimen:*—As explained before, the specimens employed in this study were designed to approximate in their major dimensions the normal size of the clasps used in appliances. In their final form, the specimens were rectangular bars 1 inch long, approximately 2 mm. (0.0788 inches) wide, and varied in thickness from about 0.5 mm. (0.0197 inches) to 1.1 mm. (0.0433 inches). These bars were formed in duplicate by casting one 2-inch bar, which was cut in two after finishing and heat treating. (Throughout this report, values of dimensions have been given either in the metric or English system, depending on the custom of practice.)

To produce this cast specimen, a rectangular bronze pattern, 2¼ inches by 2 mm. by 1 mm., was covered with a thin coating of paraffin, and surrounded with plaster in a casting ring. When the plaster was set, the ring was heated. As soon as the temperature of the plaster mold was high enough to melt the paraffin, the bronze pattern could be removed, leaving the plaster mold of the same dimensions as the waxed pattern. The temperature of the mold was gradually increased to drive off excess moisture, and finally heated for one hour directly over a large gas burner. This de-

**Fig. 8.—Area *A*, Figure 7, showing in detail crack that does not follow grain boundaries. (Reduced about one-third from magnification ×1,500.)**

veloped a temperature of approximately 600 C. in the mold, and the gold alloy was cast centrifugally into the hot mold.

In all operations of casting, an attempt was made to follow and approximate the most nearly ideal conditions used in dental practice. For that reason, a technic employing the gas-air blowpipe and centrifugal casting apparatus was used, rather than a more elaborate casting technic that would prevent possible oxidation of the metal and ensure castings of more nearly uniform quality. Such uniform castings would be ideal for testing purposes, but might be of little value in indicating results to be expected in practice.

In all castings, the same quantity of fresh metal was used. Equal pressure was applied in the casting of each specimen and the same type of mold and mold condition were used to form all specimens. The only remaining variable was the temperature of the metal at the time of casting. Since the blowpipe was used for melting, this factor of casting temperature could not be controlled, except by the appearance and the fluidity of the metal. As soon as the casting operation was finished and immediately after the casting machine was stopped of its own accord, the casting and mold were plunged into water at room temperature.

The cast specimens were heat treated as desired in a thermally controlled electric muffle furnace and the heat treatments were carried out as described by the American Dental Association specification for quenched[11] and oven-cooled treatments. After this heat treatment, the specimens were ground down to the desired size on emery cloth and, finally, each specimen was polished on cloth with levigated alumina and soap as the polishing material. Before being placed in

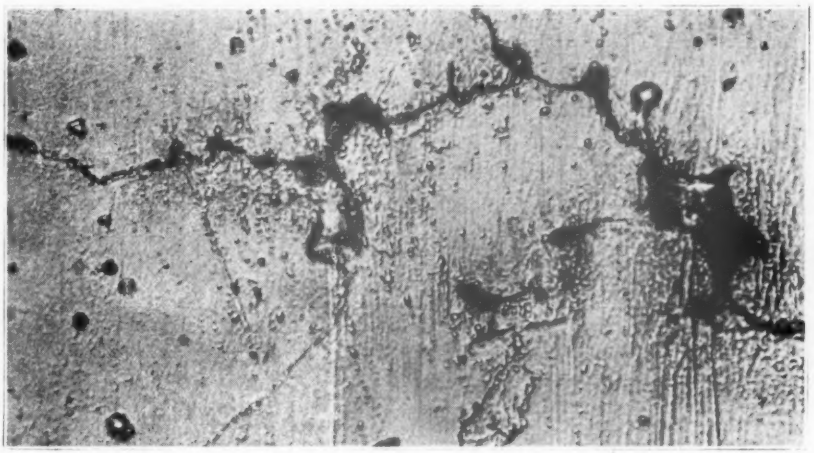

Fig. 9.—Area *B*, Figure 7, showing defective structure in detail. (Reduced about one-third from magnification ×1,500.)

11. Paffenbarger, G. C.; Sweeney, W. T., and Isaacs, Aaron: Wrought Gold Wire Alloy: Physical Properties and Specification, J. A. D. A., 19: 2061 (Dec.) 1932.

the flexure machine, each sample was examined under a binocular for such surface defects as large scratches, pits or gas pockets. Finally, micrometer measurements were taken on the width and thickness of specimens tested.

The flexure machine illustrated in Figure 1 represents the final design used in this study. The machine is driven by means of a short belt from the motor to the main shaft. On either end of this main shaft is an eccentric adjustment to control the amount of displacement in the sample, in addition to a counter to determine the number of flexures given to the test piece. Through a connecting rod, each eccentric is joined to a secondary rocker arm shaft. As each of these shafts controls three specimens by means of connecting rods, a total of six tests may be made at the same time. These connecting rods are jointed at the point *P* to allow free angular movement of the lower end of the test piece. As may be seen, the test piece is clamped in a vertical position with the upper end fixed to the adjustable upright post. This clamp may be adjusted in a horizontal position to allow for testing either by complete reversal or by bending the test piece in only one direction. The post is also adjustable vertically to permit testing of samples of greater length than those used in this study. The amount of displacement, controlled by the eccentric, is measured on the dial gage indicated in the lower left corner of the illustration. Throughout the entire six samples, the displacement may be controlled to within 0.001 inch. When a test piece breaks, the motor is stopped by means of an automatic switch that is released as the connecting rod joining the secondary rocker arm shaft to the test piece drops on the post beneath it.

To allow the belt to be placed on the pulley, the main drive shaft is made in two parts and joined by means of a grip and key device within the pulley. The machine is driven at a speed of 750 re

**Fig. 10.—Area *C*, Figure 7, showing detail of crack not following grain boundaries; typical transcrystalline fatigue crack. (Reduced about one-third from magnification ×1,500.)**

versals a minute. It is so constructed that little free movement occurs in the joints and is consequently very quiet when in operation. In all of the tests reported for this study, the test piece was deflected in only one direction from center.

This type of flexure machine is not entirely uncommon in studying fatigue on certain special metals. Townsend and Grenall[12] have reported fatigue results on sheet brass, using a fundamentally similar type of machine. In all cases, it is necessary to compute the stress in the specimen by measurements of deflection, which can be done in any one of several ways. In any standard text on strength of materials,[13] the formula for calculating the maximum stress in a beam is given as

$$S = \frac{Mc}{I}. \qquad (I)$$

Here S is equal to the maximum stress in the beam, M equals the bending moment which on a cantilever beam has a value equal to the length of the beam multiplied by the concentrated load. In this formula, c is equal to the distance from the neutral axis to the outer surface of the beam, and, for this type of beam, is equal to one-half its thickness. The moment of inertia of the beam is denoted by I in the foregoing formula, and for beams of rectangular cross-section, its value is equal to the width multiplied by the cube of the thickness and divided by 12. Thus $M = Pl$, $I = \frac{bd^3}{12}$, and $c = \frac{d}{2}$. By substituting these values into Equation I and simplifying, it results that

$$S = \frac{6Pl}{bd^2} \qquad (II)$$

This gives a usable form for calculating the stress produced in the test sample.

As will be described presently, the values for P, the pressure required to produce any desired displacement, may be determined experimentally. By substituting this determined value of P in Equation II, together with values for the length l, the width b and the thickness d, the value for the stress in the beam may be calculated. If means of experimentally determining P are not available, the values may be readily calculated from the formula

$$P = \frac{3EIy}{l^3} \qquad (III)$$

TABLE 1.— RELATION OF LOAD TO DEFLECTION

(ALLOY NO. 1)

| Load in Grams | Millimeters Deflection | | | |
|---|---|---|---|---|
| | Sample No. 5–17–2 Thickness Mm. 0.468 | 5–17–1 0.505 | 5–3–3 0.645 | 4–29–4 0.702 |
| 100 | 0.5 | 0.4 | 0.3 | 0.2 |
| 200 | 1.1 | 0.9 | 0.6 | 0.4 |
| 300 | 1.6 | 1.4 | 1.0 | 0.5 |
| 400 | 2.2 | 1.8 | 1.3 | 0.7 |
| 500 | ... | 2.3 | 1.6 | 0.9 |
| 600 | ... | 2.8 | 2.0 | 1.1 |

12. Footnote 8, third reference.

13. Boyd, J. E.: Strength of Materials, Ed. 3 (revised), New York: McGraw-Hill Book Co., Inc., 1924.

wherein E equals the modulus of elasticity of the material, y equals the deflection at the point of load application, and I and l have the same values as in Equations I and II. This gives a convenient means to determine stress values, when only the dimensions of the sample, the displacement, and the modulus of elasticity of the material are known.

A still more convenient equation is obtained when the value for P in Equation III is substituted in Equation II and the whole is simplified as

$$S = \frac{6 \frac{3EIy}{l^3} l}{bd^2}$$

substituting the value for I, and simplifying,

$$S = \frac{1.5\ Edy}{l^2}. \qquad (IV)$$

By making similar substitutions in the formula ordinarily used for calculating the stress in rotating cantilever beams, the same value is obtained as is given in Equation IV.

For several reasons, this is by far the most convenient equation to use. First, only four factors are necessary to determine the stress, and all of these are easily determined. Values for d, y, and l are all dimensions that are known for the specimen being tested. The value for E is either given for the material, or may be determined from a series of tensile tests, and need not be separately determined for each test piece, as long as the samples are prepared under uniformly controlled conditions.

In addition to possessing the advantage of convenience, this formula shows clearly the variable factors that may influence the stress exerted in this particular type of test piece. To carry this thought one step farther: This formula also shows the application of mechanics to the design of the appliance. It shows that when the modulus of elasticity, the thickness or the deflection of the structure is increased, with other values constant, the maximum stress is also increased, but as the value of the length squared increases, the stress decreases.

As already mentioned, a method has been employed to determine the deflection of the test bars when subjected to unit increments of load. The values of some observations in Table 1 have been plotted on coordinate paper given in Figure 2. These curves represent the load applied as the sample is deflected to its maximum in the flexure machine. From the straight line obtained, the load could be determined for any displacement used in the test bars. The test bar was clamped horizontally and the displacement measured at one half inch from the clamp. A more detailed description of the apparatus and the method is given in another report[14] which deals with the

Table 2.— Composition of Casting Alloys

(Per Cent by Weight)

| Alloy No. | Gold | Silver | Copper | Platinum | Palladium | Nickel | Zinc | Iridium |
|---|---|---|---|---|---|---|---|---|
| 1 | 67.8 | 12.0 | 11.9 | 2.5 | 4.0 | .... | 1.6 | 0.2 |
| 2 | 65.8 | 12.7 | 17.5 | 0.8 | 7.0 | .... | 1.0 | 0.2 |
| 3 | 63.3 | 14.4 | 18.0 | 1.5 | ... | 0.97 | 1.7 | 0.1 |

14. Peyton, F. A., and Moore, G. R.: Internat. J. Orthodontia, 19:779 (Aug.) 1933.

flexibility of orthodontic wire appliances. The system of clamping, loading and measuring displacement with the cathetometer is the same in each case. The method worked quite satisfactorily and stress values calculated by substituting the values of P determined by this method in Equation II were found to agree satisfactorily with values determined by using Equation IV. In this study, the chief disadvantage in the use of Equation II, using the observed load values, P, to calculate the stress value, was the fact that the value for the load had to be determined for each sample tested, since the thickness changed in each test piece. The result of dimensional change is indicated in Table I. For this reason, Equation IV has been used entirely to determine the stress in the test bar.

TABLE 3.— PHYSICAL PROPERTIES OF CASTING ALLOYS

| Alloy No. | Heat Treatment | Proportional Limit | Tensile Strength | Elongation Per Cent | Modulus of Elasticity | B.H.N. | Endurance Limit Lb.perSq.In. |
|---|---|---|---|---|---|---|---|
| 1 | Oven Cool | 74,000 | 97,000 | 1.0 | 13,300,000 | 260 | 51,500 |
| 2 | 700 C. Quench | 55,000 | 78,000 | 13.5 | 11,100,000 | 127 | 61,000 |
| 3 | 700 C. Quench | 40,000 | 70,000 | 23.0 | 10,700,000 | 135 | 59,000 |

## MATERIALS

In this study, three alloys of casting golds have been investigated. The chemical composition of these alloys are given in Table 2. In the absence of any set standard to govern the properties that the material must possess, this choice was made largely on account of the established reputation of the individual manufacturer to supply materials most suitable for individual needs. At the time this study was started, practically no reliable information was available concerning the physical properties to be expected of any casting gold for clasps and similar appliances. Later, brief tables and charts were prepared by some of the manufacturers which give values of some physical properties to be expected when the alloy is given certain treatments. In most cases, these properties include melting point, hardness, ultimate tensile strength, proportional limit and percentage elongation. Until this report was being typed, this was the extent of the available information, and values have not been available for a number of the other important physical properties, including endurance limit.

These alloys were chosen for this study, not for the purpose of comparing commercial products, but rather to act almost wholly as a guide in a future study of effects introduced by constitutional changes in the alloy. The original outline of this study included this constitutional change study, but because of the time consumed in designing a suitable testing machine, and making fatigue tests, this has not yet been realized. Without a knowledge of the fatigue properties of materials accepted in dental practice, any fatigue study made on specially compounded alloys for constitutional studies would be useless, until some standard was established as a means of comparison. This comparison is among the future studies suggested by this investigation.

In Table 3 are given the tensile

strength, percentage elongation in 2 inches, proportional limit, modulus of elasticity, endurance limit and (Baby) Brinell hardness number of these alloys. The different heat treatment given these alloys is also shown in Table 3. The same precautions were taken in the preparation of the tensile samples as in the preparation of flexure specimens. The tensile specimens were prepared and tested according to the method outlined by the gold group of the American Dental Trade Association[15] for tensile tests of cast alloys, since there are no standard specifications outlined by either the American Dental Association or the American Society for Testing Materials.

TABLE 4.— ALLOY NO. 1 GIVEN 0.050 INCH DEFLECTION

| Sample Number | Heat Treatment | Thickness Mm. | Stress Lb. per Sq. In. | Number Reversals |
|---|---|---|---|---|
| | Quenched from | | | |
| 1–12–1 | 540 C. | 1.009 | 153,500 | 179,000 |
| 1–12–2 | 540 | 0.960 | 145,700 | 144,000 |
| 1–20–1 | 650 | 0.898 | 136,600 | 119,000 |
| 1–16–1 | 650 | 0.884 | 134,400 | 209,000 |
| 1–16–2 | 650 | 0.884 | 134,400 | 238,000 |
| 1–27–2 | 750 | 0.870 | 132,900 | 338,000 |
| 12–3–1 | 525 | 0.850 | 129,500 | 1,270,000 |
| 1– 7–1 | 600 | 0.804 | 122,500 | 567,000 |
| 1–20–2 | 650 | 0.748 | 114,400 | 315,000 |
| 1– 7–2 | 600 | 0.729 | 110,700 | 346,000 |
| 1–27–1 | 750 | 0.728 | 110,200 | 623,000 |
| 1–15–2 | 500 | 0.712 | 107,900 | 515,000 |
| 1–18–2 | 575 | 0.700 | 106,000 | 1,661,000 |
| 1–15–1 | 500 | 0.570 | 86,800 | 940,000 |

### ANALYSIS OF FATIGUE RESULTS

In the originally designed flexure machine, the connecting rod joining the rocker arm shaft to the moving end of the test piece was a single straight rod; that is, it was not jointed at the point P indicated in Figure 1. This type of machine introduced compound stresses into the test bar and, in general, was obviously not satisfactory to obtain fatigue data. Although the stresses in the sample could not be calculated with any degree of accuracy, this machine did serve its purpose as a means of introduction to the fatigue study of casting alloys. It lent itself very well as an aid to making observations on the desirability of sound castings, uniformity in technic and general control of sample preparation. All of this served as somewhat crude, preliminary work of primitive character; nevertheless, it was valuable in the development of a machine, together with a technic that would give useful and comparable means to determine fatigue limits in cast gold alloys.

Although the machine that was used was not highly desirable from the standpoint of fatigue limit determinations, much of the preliminary work on related testing technic was satisfactorily accomplished. Later, as the study progressed,

15. Crowell, W. S.: Development of Physical Testing of Dental Materials and Specifications for Testing Methods, J. A. D. A., 19: 87 (Jan.), 1932.

developments suggested themselves which lead to the final testing machine as already described in Figure 1.

With a suitable machine available, the object was then to determine the maximum allowable stress to give satisfactory endurance values. With no guide to indicate the maximum number of reversals to be expected from a cast dental gold, and with little accurate knowledge concerning all of the physical properties and their relation to fatigue limits of the material, the first object of the study was to determine some suitable working limit.

(The other physical properties for the alloys were not known because, at the time the fatigue study was started, they did not accompany the products on the market and this laboratory was not equipped to make these tests on cast dental golds.)

In Table 4 are given the results of this preliminary study with the reconstructed flexure machine. The constants in this development were the length of the test piece and the deflection. Throughout the entire study, the length of the test piece was kept constant at 0.5 inch between the two clamps on the test piece. This was chosen as representative of a typical average structure in dental practice. Likewise, during the development stage, the deflection was arbitrarily chosen from a value considered as representative of the typical average maximum deflection to be received by a structure one half inch in length. This deflection chosen was 0.050 inch, but this was soon found to be too great. The thickness of the test sample was accordingly also arbitrarily selected in the first tests as approximately 1 mm. The samples tested and indicated by results given in Table 4 were given somewhat random heat treatments, which seem to have had practically no significance in the results obtained.

This table of data did serve to indicate that there was some relation between the thickness of the test piece of a given material, or the stress introduced, and the number of reversals obtained on the test. A general increase in the life of the sample may be seen as the stress is decreased. The stress in the sample for all the tests given in Table 4 are now known to be excessively high, but, at the time the tests were made, that fact was not so evident, and the fact that the life of the test piece had been increased approximately ten times, while the thickness of the piece had decreased by somewhat less than half, was then of much more significance. One thing further to be pointed out from this table is that, with a stress of 87,000 pounds per square

TABLE 5.— ALLOY NO. 1 GIVEN 0.050 INCH DEFLECTION; NO HEAT TREATMENT

| Sample Number | Heat Treatment | Thickness Mm. | Stress Lb. per Sq. In | Million Reversals |
|---|---|---|---|---|
| 2–4–3 | As Cast | 1.081 | 165,000 | 1.75 |
| 2–4–4 | As Cast | 1.072 | 164,000 | 1.00 |
| 2–1–4 | As Cast | 0.949 | 144,000 | 1.50 |
| 2–1–3 | As Cast | 0.948 | 144,000 | 1.00 |
| 2–3–2 | As Cast | 0.711 | 108,000 | 6.00 |
| 2–3–1 | As Cast | 0.709 | 108,000 | 1.00 |
| 2–2–4 | As Cast | 0.698 | 107,000 | 5.00 |
| 2–2–3 | As Cast | 0.557 | 85,000 | 1.25 |

inch and a life value of only 1,000,000 to 2,000,000, the test piece was only 0.5 mm. thick, which was quite thin for structural purposes.

Following these measurements, the same general practice was adopted to make tests on samples that had been given no further heat treatment than plunging into water at room temperature when cast. These data are given in Table 5. The same general observations concerning length of sample, deflection and thickness apply to the data in this table that have already been discussed for the results in Table 4. The one thing to be observed in this set of data is that, for corresponding stress values, the number of reversals is considerably greater than that given in Table 4.

At this point in the study, it was observed that the thickness of the test piece was so attenuated that, from a practical standpoint, it was valueless, yet the stress was entirely too high to allow a satisfactory number of reversals for a fatigue limit to be established. By this time, more valuable tensile data were also available, both from tests made in this laboratory and from reports made by certain manufacturers, showing that all alloys did not possess the same modulus of elasticity. An analysis of the structural design at this time showed also that this modulus was perhaps quite an important variable.

Therefore, for the purpose of acting as a guide to the study that was to follow, a table of calculated values was arranged from substitutions of hypothetical values in Equation IV. This table then showed the effect of variation of certain properties and dimensions on the stress in the sample. These values are reproduced as Table 6. From this table, the effect may readily be seen of changing the thickness of the test piece for any one deflection and modulus of elasticity. By a comparison of values, the effect may also be seen of changing the modulus of elasticity and keeping constant the thickness and deflection. Likewise, similar comparison of the effect of deflection changes in the structure or test piece may be observed. From this table, it was observed that, in

TABLE 6.— EFFECT ON UNIT STRESS PRODUCED BY CHANGING VALUE OF MODULUS OF ELASTICITY AND DISPLACEMENT
(LENGTH CONSTANT, 0.5 INCHES)

| Displacement in Inches | E=13,000,000 | | E=15,000,000 | |
|---|---|---|---|---|
| | Thickness Mm. | Stress Lb. per Sq. In. | Thickness Mm. | Stress Lb. per Sq. In. |
| 0.030 | 0.35 | 32,300 | 0.35 | 37,300 |
| | 0.50 | 46,200 | 0.50 | 53,200 |
| | 0.75 | 69,400 | 0.75 | 80,000 |
| | 1.00 | 92,100 | 1.00 | 106,000 |
| | 1.25 | 114,900 | 1.25 | 132,500 |
| 0.050 | 0.35 | 53,600 | 0.35 | 61,700 |
| | 0.50 | 76,500 | 0.50 | 88,000 |
| | 0.75 | 114,700 | 0.75 | 132,000 |
| | 1.00 | 153,500 | 1.00 | 176,600 |
| | 1.25 | 190,100 | 1.25 | 220,000 |

order to get the stress down to a suitable value and retain the necessary thickness of the sample, the deflection would necessarily need to be diminished. It was also observed that this same purpose could be accomplished by increasing the length of the test piece and keeping the deflection constant, but this adjustment did not seem desirable in view of the fact that the value for length was more nearly an ideal average constant at one half inch than was the displacement value of 0.050 inch.

Therefore, in the tests that follow, the deflection of 0.030 inch was used rather than the 0.050 inch on the one half inch sample as originally tested. The first series of values for this change of test practice are given in Table 7. Here, for the first time, there is an indication that a fatigue limit was being approached in the alloy. With as few variations as possible from the studies presented in Table 6, values began to present themselves which indicated a limiting stress to produce failure. Although the thickness of the test piece was still not the most desirable, there was evidence of an approach to a limiting stress.

The data presented in Tables 4, 5 and 7 have all been plotted in Figure 3. Disregarding the possible effects of heat treatments, the tests have all been made on the same alloy and under similar conditions, and should therefore show some relation. In considering the values obtained and plotted in Figure 3, it may be seen that a fatigue limit is being approached as the stress is decreased. The curve of Figure 3 has one other significant feature that should be pointed out. At the higher stresses, the slope of the curve is seen to change sharply; which shows the effect of severely overstressing the alloy and is similar in character to observations made on other nonferrous alloys.[17] The lower limit of this curve has been estimated from results obtained on later tests.

It is recognized that the experimental data presented thus far are only preliminary to the actual fatigue study originally intended. It has shown that a systematic course has been followed in an attempt to arrive at the suitable means to test these alloys. It will be seen that the results which follow are of considerably greater importance, but they have become possible only through the means of this preliminary work. Furthermore, it should be pointed out at this time that the preliminary work just described has necessarily been very time consuming, and these data have been very slow to present themselves for systematic study. The rate of obtaining data was retarded greatly by redesigning, readjusting and

TABLE 7.— ALLOY NO. 1 GIVEN 0.030 INCH DEFLECTION

| Sample Number | Heat Treatment | Thickness Mm. | Stress Lb. per Sq. In. | Million Reversals |
|---|---|---|---|---|
| 2– 4–2 | As Cast | 0.892 | 81,600 | 1 |
| 2–16–2 | As Cast | 0.874 | 79,800 | 5 |
| 2– 4–1 | As Cast | 0.851 | 75,100 | 1 |
| 2– 3–4 | As Cast | 0.818 | 74,000 | 1 |
| 2– 3–3 | As Cast | 0.818 | 74,000 | 5 |
| 2– 2–2 | As Cast | 0.654 | 59,000 | 20 |
| 2– 2–1 | As Cast | 0.637 | 58,000 | 10 |

17. Footnote 8, third reference.

even rebuilding the flexure machine a number of times, as well as using in the early stages of the study, a machine in which only one sample could be tested at a time. As all of this has retarded the progress of the work, the preliminary studies have assumed greater importance than would be justified had more data been collected on the final machine form.

Using the final machine design (Fig. 1), alloy No. 1 was studied in the oven-cooled condition over a systematic change of thickness, or maximum stress. The thickness limits were designed to cover the range from 1 to 0.5 mm., with deflection of 0.030 inch and a length of 0.5 inch. The heat treatment employed was chosen with the idea of obtaining a uniform treatment throughout the series; yet by using the oven-cooled treatment, the metal would possess properties entirely different from those in any of the tests described previously. Thus, an entirely new, but strictly analogous, set of conditions and properties within the series would be established.

The results are shown in Table 8 and have been plotted in Figure 4. An analysis of the data shows that a typical set of values for fatigue limit tests have been obtained. The number of reversals obtained increases uniformly as the stress is decreased, until a point is reached at approximately 51,000 pounds per square inch, beyond which a decrease in stress produces no apparent change in number of reversals obtained. The limit of the number of cycles has been selected as 25,000,000, although some tests have been run to a greater number of flexures without failure.

TABLE 8.— ALLOY NO. 1 GIVEN 0.030 INCH DEFLECTION; OVEN COOLED

| Sample Number | Heat Treatment | Thickness Mm. | Stress Lb. per Sq. In. | Million Reversals |
|---|---|---|---|---|
| 5- 2-2 | Oven Cooled | 0.995 | 90,800 | 1.5 |
| 5- 2-1 | Oven Cooled | 0.993 | 90,300 | 2 |
| 1-28-1 | Oven Cooled | 0.950 | 86,800 | 2 |
| - 3-1 | Oven Cooled | 0.788 | 72,100 | 3 |
| 5- 3-2 | Oven Cooled | 0.774 | 70,600 | 4 |
| 5- 4-2 | Oven Cooled | 0.770 | 70,600 | 5 |
| 4-29-1 | Oven Cooled | 0.738 | 67,300 | 6 |
| 2- 3-1 | Oven Cooled | 0.707 | 64,700 | 6 |
| 4-29-2 | Oven Cooled | 0.702 | 64,200 | 8 |
| 5- 3-4 | Oven Cooled | 0.650 | 59,300 | 7 |
| 1-10-2 | Oven Cooled | 0.646 | 59,200 | 10 |
| 2-15-2 | Oven Cooled | 0.563 | 51,500 | 25 |
| 2-11-1 | Oven Cooled | 0.561 | 51,300 | 25 |
| 5-17-1 | Oven Cooled | 0.505 | 46,200 | 25 |
| 2-15-1 | Oven Cooled | 0.474 | 43,400 | 25 |
| 5-17-2 | Oven Cooled | 0.468 | 42,800 | 25 |

These data have been plotted in semi-logarithmic coordinate graphs and have produced the typical stress-endurance curve, with its break indicating the maximum stress possible without failure. This method of plotting, which is customary in fatigue studies, may be observed in any reference work on fatigue of metal.

This same approach was made to the study of alloy No. 2. Since the alloy was used in the quenched condition, it

possessed physical properties entirely different from those of alloy No. 1, in the oven-cooled condition. This is best observed in Table 3, which gives the physical properties of the alloys. This method of comparison rather than different heat treatment on alloy No. 1 was used in order to show a maximum of change in physical properties, while the change would probably not be so great in considering different treatments of the same alloy No. 1. The results are given in Table 9 and Figure 5. Comparing the results obtained on alloy No. 2 with those on alloy No. 1, it is interesting to observe that the maximum stress which may be introduced without failure is only a little greater than for alloy No. 1, while the thickness of the test piece is between one-fourth and one-third greater than that used in alloy No. 1. It must be kept in mind that these two alloys

TABLE 9.— ALLOY NO. 2 GIVEN 0.030 INCH DEFLECTION; QUENCHED

| Sample Number | Heat Treatment | Thickness Mm. | Stress Lb. per Sq. In. | Million Reversals |
|---|---|---|---|---|
| 11– 1–1 | 700 C Quenched | 0.957 | 74,600 | 4 |
| 11–15–2 | 700 C Quenched | 0.910 | 70,800 | 3 |
| 11– 8–2 | 700 C Quenched | 0.898 | 70,000 | 8 |
| 12–22–2 | 700 C Quenched | 0.882 | 68,800 | 14 |
| 10–15–2 | 700 C Quenched | 0.838 | 65,300 | 21 |
| 11–15–4 | 700 C Quenched | 0.785 | 61,000 | 56 |
| 12–22–1 | 700 C Quenched | 0.762 | 59,300 | 15 |
| 11–29–2 | 700 C Quenched | 0.728 | 56,700 | 55 |
| 12–20–2 | 700 C Quenched | 0.709 | 55,200 | 33 |
| 11–10–2 | 700 C Quenched | 0.708 | 55,100 | 26 |

TABLE 10.— ALLOY NO. 3 GIVEN 0.030 INCH DEFLECTION; QUENCHED

| Sample Number | Heat Treatment | Thickness Mm. | Stress Lb. per Sq. In. | Million Reversals |
|---|---|---|---|---|
| 6– 2–1 | 700 C Quenched | 1.056 | 79,400 | 2 |
| 6– 2–2 | 700 C Quenched | 1.031 | 77,750 | 4 |
| 6– 1–2 | 700 C Quenched | 0.915 | 68,500 | 13 |
| 6– 1–1 | 700 C Quenched | 0.833 | 62,700 | 33 |
| 5–31–2 | 700 C Quenched | 0.798 | 59,600 | 24 |
| 8– 8–1 | 700 C Quenched | 0.798 | 59,600 (defective) | 1 |
| 8– 8–2 | 700 C Quenched | 0.736 | 55,400 | 28 |
| 5–31–1 | 700 C Quenched | 0.685 | 51,500 | 24 |

alloy. It should be stated that these modifications are being carried out on each alloy, but time has not permitted their completion. For the present, therefore, a comparison must be made between different alloys.

The results obtained on alloy No. 2 are interesting in that they show a similar uniformity of relation of thickness to stress, and number of flexures, as did were not given the same heat treatment; and this cannot therefore be interpreted directly to mean that alloy No. 2 is superior to alloy No. 1, only when compared in the light of the different heat treatments received. This difference in correlation of results and thickness is probably due to the difference in the modulus of elasticity of the two materials, which enters into the formula for

calculation of the stress in the test piece. In connection with these data on alloy No. 2, it may be observed that two samples near the fatigue limit value were given more than 50,000,000 reversals without failure.

Using the same method of approach in studying alloy No. 3, it is to be observed that similar results have been obtained. The data are presented in Table 10 and Figure 6. This alloy was given the same heat treatment as alloy No. 2, and a comparison is shown between two alloys of different composition and slightly different properties when given similar treatments. It is to be observed that, although the limiting thickness to give 25,000,000 flexures is approximately the same for the two alloys, the maximum stress in alloy No. 3 is slightly less. Here again is evidence of the effect of change of modulus of elasticity of the material. In the absence of more ample proof, this comparison of the three alloys tested at present indicates some uniformity of change in maximum stress to be expected by changing the thickness of the test piece and the modulus of elasticity of the material.

The photomicrograph shown in Figure 7 represents a typical fatigue crack of a cast gold alloy. The photomicrographs in Figures 8, 9 and 10 show sections of the fatigue crack at higher magnifications. Figure 7 shows the fatigue crack to be typical of fatigue failure, as the crack is transcrystalline in nature and follows a path which includes two defective portions of the test piece. The defective sections are probably oxide pits and represent points of maximum stress concentration. The effects of similar defects have been discussed by other investigators,[9] and it has been pointed out that these points of maximum stress often are included in the path of progressive fracture, and possibly have acted as centers from which the cracks start. The transcrystalline nature of the crack is best shown in the photomicrographs at higher magnification.

From the data in Table 3 and the fatigue results on the three different alloys, there has been no observation of a relation between the endurance limit and the tensile strength, proportional limit or percentage elongation of the alloy. A decrease in the endurance limit is indicated with the increase in Brinell hardness. The ratio of increase of hardness between the three alloys is much greater than the corresponding decrease in endurance limit.

The modulus of elasticity shows no direct relation to the endurance limit. Nevertheless, from a structural standpoint, it does assume an important position. This is best brought out in Tables 8, 9 and 10, where the thickness of the test piece, the stress introduced during flexure and the number of repeated stresses are listed for each of three alloys. It should be pointed out again that comparison of results on alloy No. 2 with those on No. 3 indicates that the thickness of the test piece is greater in No. 3 than in No. 2, yet the endurance limits of the two are practically the same. This seems to emphasize the fact that, structurally, the alloy with the lower modulus of elasticity may be made to considerably greater dimensions than one with a high modulus of elasticity, before the stress becomes dangerously high for unit deflection and length. This is true provided the fatigue limit of the alloy is correspondingly sufficiently high.

A review of the results obtained from this investigation suggests that an important problem for future study would be a continuation of the consideration of design of cast appliances on the basis of

stress introduced, together with the properties of the materials used for construction of these appliances.

SUMMARY

1. A flexure machine has been developed which is suitable for making fatigue studies on cast dental gold alloys.

2. The modulus of elasticity may be a very important property from the standpoint of design of the structure.

3. There is no outstanding evidence of a relation of fatigue limit to the other physical properties. The shape of the fatigue endurance curves for these alloys is similar in character to those published previously for other metals.

4. The fatigue failure is across the crystal of the material, as shown by photomicrographs. This indicates that the type of failure in gold alloys is similar to that in other alloys.

# HISTORICAL REVIEW OF THE MAJOR EPISODES IN THE ATTAINMENT TO THE SCIENTIFIC CONCEPT IN OPERATIVE DENTISTRY*

By FREDERICK S. McKAY, D.D.S., New York City

HISTORY too often concerns itself with personages who have long since passed away and with events so far removed in antiquity as to have been all but forgotten.

The unfolding of the history of nations and of human society has been measured only in centuries, and it has been true only too often that long periods must pass before the contribution of an individual to his epoch and to the future can be rightly evaluated.

In recounting the achievements of dentistry during the century of progress, for which purpose this congress has been included in this great exposition, we shall find our major episodes and human figures well this side of the distant century mark, and well within the ken, in personal recollection, of many who may today hear these words.

It has not been necessary that these master builders lie through centuries of oblivion before the world could measure their value.

If dentistry has progressed rapidly, how important it is that the signposts along the road have pointed straight, and said, "Here lies the way." Those who have travelled many of the weary miles of our road, as well as those who have more lately come upon it, can together journey back with a sense of heightened appreciation to see whence we came, and discover where the road came out of the wilderness.

We shall see many pathways leading off to one side or the other, and mansions erected along the way that have long since been abandoned and have crumbled to ruin. These episodes can be evaluated only by going back and living them again,

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To search for the first allusions to diseases of the teeth is to go back to antiquity. The time when dental caries was not is beyond our knowledge. The Papyrus of Ebers, 3700 B. C., mentions diseases of the teeth and gums and gives prescriptions for their treatment.

Egypt undoubtedly became the cradle of dentistry through the Pastophori, a priestly order of 850 B. C., who derived their authority from six of the forty-two books of their bible, these six books being devoted to the healing art.

**In Hippocrates, 460 B. C., we have the first analytical student of medical science. He was the first to know and describe the period of eruption of the teeth, their diseases, their treatment by operation, and dentifrices.**

**He deserves the admiration of all progressive men. Living in an age of superstition in which the supernatural governed science and the healing art, he had the ability to discover natural causes and physical agencies, and the courage to proclaim them in spite of the opposition of long rooted prejudices.**

In the "Awakening of Western Europe After the Crusades," Fallopia and Eustachi were the real discoverers of anatomy. Then came the first reasonably correct description of the human teeth. Fallopia discovered the dental follicle.

Do we believe that the era of specialization is of recent origin? In that epoch, there were oculists and aurists, and dentists were developed.

The title "doctor" was invented in the twelfth century with the establishment of universities. This title was first bestowed by the College at Asti, Italy, in 1329.

The title "surgeon dentist" was first given in 1632 in France. Dentistry began to receive distinct recognition in the sixteenth and seventeenth centuries, and increasing evidences are found of methods of repair, medication, treatment and prophylaxis.

It is with a peculiar sense of fitness that we contemplate for a moment what we now know to have been the one major event in the early history of dentistry, the invention of the microscope by Antony van Leeuwenhoek, in Holland, the tercentenary of whose birth, Oct. 24, 1632, has received recognition during the past year by scientific societies.

With that crude instrument fashioned by his own hands, he was the first to look on an entirely new world beyond the range of the human eye, and, as a recent writer has put it, "a world peopled with a thousand different kinds of tiny beings, some ferocious and deadly, others friendly and useful, many of them more important to mankind than any continent or archipelago."

Bacteria were first observed in 1676 and given their first adequate description in the eighteenth letter written by van Leeuwenhoek to the Royal Society of Holland, dated Sept. 14, 1683.

It is of further peculiar interest to us to note that, in a letter from him to Francis Ashton, Fellow of the Royal Society of London, he describes "very little animals moving in a very lively fashion," which he discovered in the white substance adhering to his own teeth, animalcules he called them. These were the first bacteria the human eye ever saw.

Leeuwenhoek went farther and, in 1678, gave the first description of the tubular structure of the dentin from observations made on one of his own teeth. Others who observed with him agreed that the structure was made up of very small straight pipes, 600 or 700 of which were about the thickness of one hair. This language was so new and so far beyond the understanding of that period that little attention was paid to it.

It was not until about 200 years later that Leeuwenhoek's great invention was applied to dental science.

The very antiquity of dental decay

makes it obvious that, in the search for its cause, many theories, some of them unbelievably fantastic, would be erected and would find adherents.

The venerable father of medicine, Hippocrates, in the fourth century B. C., attributed it to the stagnation of depraved juices accumulated in the teeth. The nutritional school of the present day has the benefit of precedent in the view of so distinguished an antiquarian as Galen (131 A. D.), who ascribed the cause to a "disturbance of nutrition."

The pages of history would have to be well thumbed even to list the vain searchings of the mind, but as we come down the years, certain outstanding theories are disclosed that became for the time well established, and even persisted surprisingly close to the beginning of our own era.

To consider the worm theory briefly as one of these, indeed one of the most fantastic, it is necessary to state that even as late as the seventeenth century, it was a popular belief that worms caused caries and were to be found in the cavity of decay.

It adds not a little to our estimate of Fauchard to review in his writings in the early part of the eighteenth century his critical and searching analysis of that theory, which apparently had the effect of discrediting and setting it aside. His disagreement with it was logical and emphatic.

In those early times, when man's existence was hedged about with superstitions, disease of the teeth was treated by incantations, prayer and even disgusting and absurd applications. The temples were cauterized with fire, and medicines put into the ears, for the reason, as one writer put it, that "the small veins by which nourishment is carried to the teeth do run by the ears."

Ambroise Paré, during the middle of the sixteenth century, regarded the teeth as bones, and caries in the two as identical, which view evidently prevailed sufficiently up to the beginning of the nineteenth century to warrant Fox, in 1806, in propounding what came to be known as the "inflammation theory."

He differentiated between caries of the teeth and that of bone on the basis only that the teeth do not possess sufficient living power, as he expressed it, to effect the process of exfoliation.

With the first enunciation in the United States, by L. S. and E. Parmly, of the chemical theory, in 1821, we have the dawn, in the literature at least, of a rational approach to the cause of dental caries.

A startling clarification of what the Parmlys had announced came from Roberston, of Birmingham, England, in 1835. He gave what is really the first definite enunciation of the chemical theory: "The only cause capable of explaining the partial operation and the particular situations of decay is the corrosive or chemical action of the solid particles of food which have been retained and have undergone a process of putrefaction or fermentation in the several parts of the teeth best adapted for their reception."

Robertson here set out two of the foundation precepts of dental caries; namely, its localization and the process of putrefaction or fermentation, between which he could not, of course, at that time perceive a differentiation, but which, as was shown later, was of extreme importance.

The human mind apparently never tires of theorizing, for which fact this paper is not apologetic. The quest for knowledge and yet more knowledge compels it, and the theorizers of that day, although fewer, lacked none of the enthusiasm of those of the present day.

Desirabode, in 1846, would divide caries into two expressions: When caused by chemical action, it proceeds from without inward, but when it arises from a pulp injury, it proceeds from within outward.

Nor was John Tomes, in 1859, entirely lacking in sympathy with the inflammatory theory. His studies of the pathology of caries contributed much to his era, notably in the formulation of the "chemicovital" theory. In this he held that caries was "to some extent inflammatory" but that in other of its expressions, "the vitality of the tooth was at least a resisting force." The latter phrase is not so strange to our ears at the present day.

Magitot, in 1867, had, as we have seen, some authority for his rejection of the inflammatory theory, and as to the idea of a division of caries into varieties, he would have none of it. Emphatically he declares "caries is one," but he divides the disease into periods, the cause in each being purely chemical. He has first, superficial caries, or caries of the enamel; second, middle caries, and, third, deep or penetrating caries. Further, he claimed to have produced caries artificially, except as to certain minor phenomena.

I ask you to go back with me into the lecture room as a student, in a hallowed recollection of the venerable James Truman and his teachings. In his lectures on dental pathology, allusions to the researches of Leber and Rottenstein frequently fell from his lips, and the fact that, after all these years, those names lingered in my memory is ample evidence that he found in them something that illuminated his discourse.

Not through any lack of his impressiveness as a teacher did I find myself recalling in these anything but names, but only when in preparation of this treatise did I recognize the fundamental import of their achievements.

When we come to their studies in 1868, there begin to emerge the significance and value to us of the crude microscope tube and lenses so laboriously fashioned by Leeuwenhoek almost 200 years before.

The work of these two investigators entitled "Dental Caries and Its Causes" was translated into English by Dr. Chandler of Boston in 1873. In it, they advance the theory that caries is caused by the fungi of the mouth, chief of which was *Leptothrix buccalis*. It had long previously been discovered that vegetable organisms existed in the oral cavity, but as this was supposed to be accidental, little weight was attached to the fact.

Having demonstrated the presence of these fungi in the dentinal tubuli, and noted the expansion of the tubuli, to which much importance was given by later investigators, Leber and Rottenstein attached an important influence to these organisms in the carious process. They held that acids alone could not account for all the phenomena of caries, noting differences between the effects of simple acid action and those phenomena. Decalcification must precede the action of the fungus.

Caries of the enamel they differentiated sharply, as a process purely chemical.

It is not possible to read the literature of that period without encountering frequently the names of Underwood and Milles, who, at the International Medical Congress in London, in 1881, set forth their convictions that caries was due to micro-organisms acting directly on the dentin structure without any intermediate or preceding process, destroying the living matter and leaving the inorganic matter to be broken down and washed away, by what process they fail to record.

Opposed to such a theory was Magitot's declaration just prior, in 1878, that caries was purely a chemical alteration of the enamel and "ivory" as the dentin was then called.

The field is ready for the master hand.

At a meeting of the American Dental Society of Europe held at Wiesbaden, Germany, in 1881, there appeared as an essayist a young dentist previously unknown, Willoughby D. Miller, born and graduated in America, who a year previously had attached himself to Koch's laboratory in Berlin, for training in research.

The paper he there presented, the first of a long series, gave the initial results of a course of experiments and observations that were new to the science of dentistry. His association with Koch had given him a familiarity with technical procedures that well fitted him for a later searching and complete examination into the subject of dental decay.

In addressing himself to this task, he was motivated by the spirit and the demands of the scientific attitude. His search was to be for facts.

It would seem that the custom in research in those days was to start with a preconceived theory and endeavor to make the findings conform thereto. Miller's plan was just the opposite. His experiments began without a theory and his deductions were built upon the facts that he established.

He proceeded systematically by cutting literally thousands of sections of decayed teeth, and subjecting them to every conceivable technic then known, through which he demonstrated the invariable presence of bacteria within the dentinal tubuli. He made the deduction that decay was essentially connected with their presence and influence. Underwood and Milles had preceded him to this point.

But in what way were these organisms essential?

He cultured, segregated, and studied their life histories. It was a full year before he was able to isolate certain of them in pure culture. Moreover, he differentiated between caries of the enamel (which term I use with reservations) and caries of the dentin, and between the processes of fermentation and putrefaction, particularly in reference to decay, and finally produced decay of the dentin in an artificial environment that was not distinguishable under the microscope from natural decay.

Of the conceptions that had previously been held dealing with the nature and cause of decay, there was little left when Miller had published the results of his investigations.

He set forth in exhaustive detail the vital manifestations of bacteria in the reduction of certain sugars into simpler forms: the sources of nutrition, for micro-organisms in the mouth, particularly the carbohydrates, and the reduction of these substances into lactic acid in the fissures and other protected areas on the teeth. Magitot had shown in 1868 that lactic acid in a dilution of one to a thousand could decalcify enamel. In establishing the last point, Miller lifted the nature of the initial process in decay from obscurity to a demonstrable fact, and endowed these organisms with a property that had hitherto been unperceived, the property of bringing about fermentation.

The closeness of the approach of Underwood and Milles, of Leber and Rottenstein, of Robertson and of Regnaud, is measured by their failure to understand the influence of micro-organisms in inducing fermentation, with its acid end products.

Liebig, after centuries of discussion of that process, had put it into tangible form

after the discovery of the yeast plant in 1838.

The works of Schwann, Lister and Koch had shown the agency of micro-organisms in the fermentation process, which was considered a new theory that had to be explained. With the understanding that this process is a remolecularization of the substance undergoing the change, it stands as the connecting link between micro-organisms and decay.

In the work of Pasteur and others following, it was shown that there was no fermentation nor putrefaction without organic germs. In this way was the germ theory substituted for the old molecular motion theory of Liebig.

Miller's experiments with saliva determined that if organic germs were excluded, it contained nothing that could bring about the generation of an acid. It is not strange, therefore, that we should find Miller devoting no little attention to the inflammatory theory, which you will recall had become well established. He says:

> It is not possible to produce decay or anything resembling it by means of any or all of those mechanical or chemical agents which invariably produce inflammation in other tissues. We all know very well that we may file, grind, saw, bore and pound the living dentin, we may break away large portions with the forceps or subject it to the action of the most irritating substances; we cannot produce in this way a trace of caries. The operation of filling teeth is of itself a continued testimonial to the inconsistency of the inflammatory theory of decay, for we know very well what would result if we should bore a hole in any tissue capable of inflammation (bone) and pound it full of gold.

He points out further that teeth from which pulps have been removed which are mounted on pivots or worn on plates, as was somewhat common practice at that time, are subject to decay the same as teeth with vital pulps, and, when decayed, they show the same microscopic changes in the structure.

John Tomes, in 1873, had concluded that "caries is the effect of external causes in which the so-called 'vital' forces play no part," but is due to the solvent action of acids generated by fermentation going on in the mouth.

No theory up to that time had been so generally accepted as what was known as the "chemical" theory, in dealing with which Miller showed that the microscopic changes characteristic of decayed dentin could not be produced by any acid alone.

To perceive clearly what Miller's background had been in directing his researches so definitely along the bacterial aspect, we note his acknowledgement to the Dresden physician Ficinus in 1847 and to Professor Erdl two years in advance of that. The main tenets of Miller's position had, as we have seen, been very closely approached by Leber and Rottenstein and by Underwood and Milles.

We are now ready to state the essence of Miller's findings.

"Dental decay," he states, "is a chemico-parasitical process consisting of two stages, the decalcification of the enamel, which results in its total destruction, and the decalcification of the dentin as a preliminary stage, followed by the dissolution of the softened residue. The acid which effects this primary decalcification is derived from the fermentation of starch and sugars lodged in the retaining centers on the teeth." Starch is held to be equally responsible with sugar in the beginning of this process.

An extremely important point brought out is that cane sugar as such is not fermentable, but in a mixture of starch and fungi, through a reduction process, sugar in *statu nascendi* is rapidly resolved into lactic acid.

The intensity of the fermentation occurring in the retention centers determines the rapidity with which the de-

struction of the teeth proceeds, the latter being inversely proportional to the density of the tooth structure.

In expounding the facts determined by his investigations, Miller was a voluminous contributor to the *Independent Practitioner* and the *Dental Cosmos* of that period. Not the least of the interest to be derived from exploring the dusty volumes of these journals lies in observing the reactions of contemporaries to the projection of these revolutionary doctrines.

Those chronicles of dental history reveal only too plainly the measure of opposition that met Miller's statements, being, as they were, directly opposed to everything then believed.

It seemed curious that America, after the acceptance of his conclusions by Germany, England and France, slowly became conscious that one of her own sons had achieved the solution of an age old problem.

In the journals of that era will be found opinions discrediting the demonstrated relation between bacteria and the fermentation process, and arguing instead that bacteria are the result of fermentation rather than the cause.

With the facts so well established, it is not strange to find Miller betraying some impatience with those authors and others of that time who scouted the idea of any relationship between the presence of bacteria and the processes of putrefaction and fermentation.

The chemicoparasitic theory of decay, sharply distinct from the chemical theory, came into prominence about 1881 and steadily gained acceptance. The obstacle to its more rapid acceptance was the lack of knowledge concerning the growth and physiologic action of the fungi of the mouth, but it was established that any fungus which can bring about fermentation of starch or sugar may be instrumental in bringing about the first stage of decay; that any which have a peptonizing action brings about the second stage by dissolving the dentin, and that any which possess both actions will accomplish the whole process of decay, and there are many such in the mouth.

By 1891, the disputatious voices had all but ceased, and this great contribution of Miller stood in acceptance. He significantly stated at that time that "bacteriology had brought about a revolution in medical science within the ten years just previous, as has not taken place since the time of Hippocrates."

But these revelations of bacteriology had brought about a state of mind in which a fear of microbes overshadowed all else, and which it seemed necessary for a certain vigorous and well-known writer and speaker of that time to rebuke.

Addressing his colleagues, he said: "Climbing out of the cellar of ignorance we have not stopped at the first floor of reason, but have rushed into the garret of fanaticism and bigotry. The great trouble is that many men cannot imbibe a single draught of knowledge without becoming craniologically intoxicated."

He further admonished them by quoting Pope's immortal verse:

**A little learning is a dangerous thing:**
**Drink deep, or taste not the Pierian spring:**
**There shallow draughts intoxicate the brain**
**And drinking largely sobers us again.**

The chief storm center of that period contemporaneous with and just following the researches of Miller raged around what was known as the Heitzmann theory of the formation and structure of the tooth tissues, which was made to bear out and support the inflammatory theory of decay. Heitzmann and the principal supporters of these theories, C. F. W. Bödecker and Frank Abbott, formed a triumvirate of compelling and powerful

tenacity in the effort to establish them.

The underlying basic idea as published by C. F. W. Bödecker in 1878 laid down as its chief fundamental the vitalistic nature of the enamel. This tissue was then described as containing interstices between the enamel rods that contained delicate fibers of living matter. These fibers, he said, maintained a direct connection with the dentinal fibers, which could often be observed at the dentin-enamel junction. This theory had the effect as then expressed of raising the enamel to the dignity of a living tissue, instead of its being considered as merely a calcareous deposit.

If Miller and those who later substantiated his findings could be considered from Heitzmann's standpoint as outlaws, Heitzmann himself could be considered as nothing less in relation to certain biologic concepts previously established. As witness to this, we find him announcing his discovery in 1873 that there does not exist a tissue within the animal body that is built up of individual cells, as taught by Theodore Schwann, and that what was formerly thought to be a cell has been recognized since 1861 as so-called protoplasm, but his differentiation on this point is not made clear.

Heitzmann, in this way, sweeps the cell theory out of existence. As a substitute for the cell theory, he offers what was known as the "bioplasson" theory of morphologic structure. It is not necessary to undertake a complete dissection of this elaborate hypothesis. In brief, it sets forth that the living matter pervades every part of animal organisms as a continuous net work or reticulum, and that the tooth tissues are thus pervaded in common with the other structures. According to that theory, the building of enamel and dentin is accomplished by the calcification of successive layers of corpuscles.

In the application of that theory to our subject, caries was held to be the "unbuilding" of these layers, during which they were decalcified and liquefied, and were ultimately returned to the original elements from which they were formed.

Considering the discrepancy between his own findings and this theory, it is not surprising to find Miller in disagreement with it. He thinks it strange that inflammation of the dentin has not been observed by others. He calls for further evidence, and feels that the opinions and explanations of writers such as Abbott are due to a misinterpretation. The liquefying reduction of the basic substance of dentin, he observes, cannot be found when bacteria are not present.

By 1888, the ideas of Miller had gained strong support, furnishing, as they did, a reasonable and demonstrable explanation of decay. The revolutionary aspect of his conclusions was in the nature of a challenge to find out, first of all, whether they were correct, and, secondly, to carry the investigation farther in the search for evidence that would substantiate the major premise.

In demolishing theories in which the minds of men have abided in fancied security, new theories are bound to arise to which the troubled mind may flee and in which peace and comfort may again be found. It requires courage to level an edifice reared as a temple in which Truth has been assigned an abiding place, and woe be unto him who tears down without putting in its place a structure whose foundation stones are securely laid.

Such a builder must be one whose shoulders are broad, whose courage is staunch, whose energy is tireless, whose mind goes straight and who will be satisfied with nothing less than to know that he knows.

Miller's work had to be repeated and confirmed if it was to stand. It was

necessary to understand better the phenomena that he had described. The physical nature of the structures acted on, the teeth, must be better revealed. Finally, the completed knowledge must be brought into relation with technical procedures. In other words, the scientific must be made practical.

We have been prone to draw a line between the scientific and the practical. The late Edward C. Kirk once said: "What is scientific in the true sense of the term must be necessarily also practical. Nothing is more practical than the truth, and science must be true, else it is not science."

The answer to that challenge is the epic of that era during which G. V. Black illuminated the annals of dental science. Curiously, again we have an example of contemporaneous workers. Black was at the same time doing bacteriologic work on the cause of caries that completely upheld Miller's. We have in him an amazing combination of the scientific with the practical.

At the outset, in one of his voluminous published articles, in 1886, he states his definition of caries, the most concise statement up to that time, in these words:

> Dental caries is a chemical disintegration of the elements of the tooth molecule by molecule, usually beginning at some pit, groove, or other irregularity, at the point of contact on the proximal surface, or at the neck of the tooth. Such places are protected from the friction of mastication and the movements of the lips and tongue, thus favoring the lodgment of particles of food until fermentation takes place, resulting in the formation of products that decompose the constituents of the tooth.

Black make some curious observations on the older theories, but particularly in reference to the origin of the practice of filling teeth in relation to the inflammatory theory. Relief only from the progress of the disease was expected, but it rapidly became the custom to fill to cure. Obviously, if decay was the result of vital forces within the tooth, filling would only increase the damage. Commenting on the recorded observations of such writers as Robertson in England, in 1835, and Regnaud in Paris, in 1838, that caries started in definite circumscribed areas, Black considers it remarkable, that since fermentation was not then understood, they approached so nearly to the truth.

Black's inquiries into the physical properties of tooth structure, the tooth surfaces and the environment of the teeth in their relations with the phenomena of decay, precipitated one of the most controversial episodes in the history of dentistry.

In deciding on this investigation, Black was influenced by the fact that the physical character of the human teeth in relation to decay had never been subjected to scientific inquiry. The prevailing thought was that the condition of the tissues of the teeth was the determining factor. Miller's studies had included but little consideration of that phase.

In a lecture before the American Dental Society of Europe, in 1885, we find Miller observing that while many experiments had been made by physiologists for the purpose of determining the action of inorganic substances, such as phosphate of lime, on bones, there had been no experiments of like nature with reference to the teeth; that clinical evidence alone had been relied on, and this had been so conflicting that, after a discussion of fifty years, they were no nearer a solution.

Based on nothing more than clinical observations, such terms as "frail," "chalky," "hard," and "soft," were frequent in the literature. Moreover, physiologic behavior that warranted inquiry was ascribed to the teeth. For example, the resumption of active decay was interpreted as meaning that the teeth had become soft through the withdrawal of

lime salts by processes that reflected systemic changes.

Black's argument was that, of all tissues, the teeth were the least subject to vital changes, and for that reason the vital condition of the tooth had little to do with it. He held that the carious attack was entirely from the outside.

In his differentiation between predisposing and active causes, he lists faulty tooth formation as the most effective of the predisposing causes, their significance being that they give opportunity to the disease. Faulty formation he classified in two varieties: deviations from the normal in form, and deviations of the integral structure. An acid that dissolves lime salts does so whether the structure is good or bad, the density of the structure governing only the rapidity of solution. Deviations from the normal formation have reference to the physical form and not to the chemical or molecular composition.

By "deviations from the normal physical form," he clearly means pits and fissures, the presence of which is today recognized as the chief problem in establishing measures for the prevention of carious damage, and in accounting for the formation of which we seem to stand helpless.

It was, therefore, of intense interest to note Black's explanation of these breaches of continuity of the tooth surface that we call fissures and pits (the only explanation of which I am aware) to the effect that the enamel formative membrane is not sufficiently broad to dip down into the center of the depression that has been caused by the more vigorous growth of the dentin carrying the cusps farther apart, leaving a gap that is finally represented by a fissure.

In carrying out the studies which he described in the literature of that period in a collection of articles and chapters that were unique at that time, and indeed up to the present, in conciseness and definiteness of expression, he accomplished a task herculean in its proportions. For hours and days on end in his laboratory, with instruments that had to be devised and constructed for the purpose, he projected his inquiries into the very core of the physical, chemical and biologic properties of the matter under investigation.

The essence of his conclusions was to shift completely the concept of the nature of the factors in the process of decay.

In his consideration of the teachings of Heitzmann, it was not the theory of tooth embryology, as such, that drew Black's shafts of criticism, so much as it was that part of the theory which denied the cell basis of organic life, particularly as regards the fermentation process.

In discussing this, Black pointed out the various end-products of cell life: urea in the animal; alkaloids and organic acids in vegetable life; alcohols, organic acids in certain microbes, and ptomaines or toxins in others. Such substances are the result of the remolecularization of matter under the influence of the vital processes of living cells. Such is fermentation.

If men's minds are driven through sheer compulsion from the inflammatory theory, to what shall they fly? Were there not differences in the physical appearances of the teeth and in their resistance to cutting instruments, and in their liability or proneness to decay as between individuals, and was it not to be assumed that these were due to the varying amounts of lime salts incorporated during the calcification process?

Black, through long months of testing, cutting, analyzing, weighing, measuring and, above all, thinking, had determined that the difference in degree of calcification, or content of lime salts, or resistance to crushing stress, was, as between different teeth, or the teeth of different indi-

viduals, of so inconsequential a variation as to be unrelated to the fact of decay.

"There is not sufficient difference in the structure of the teeth themselves," he says, "to account for the manifest differences seen in practice. The strongest and best formed teeth fall prey to caries and are rapidly destroyed, while in other cases teeth not nearly so good, either in form or structure, are not affected."

In one particular do teeth all agree, their solubility in acid. It has taken many years to furnish satisfactory proof of this fact as set forth by Black. Recent work has demonstrated that enamel notoriously defective in its integral structure is not thereby rendered more liable to decay than is enamel which is to all intents and purposes normal. But at the time Black's dictum was promulgated, and indeed for long years afterward, it was nothing short of heresy.

In arriving at that conclusion, many facts had to be established. Clinical observation seemed to indicate that the teeth of different individuals presented strong personal characteristics as to density, which was assumed to stand in relation to the amount of lime salts. Black's studies showed that there were these differences, but that they were almost nil. They showed also that there were differences between different teeth of the same individual, much greater than the average difference in different persons. Neither was it found that the specific gravity, nor the ability to stand crushing stress, was directly dependent on the amount of lime salts.

He was, therefore, led to state that neither the density nor the percentage of lime salts had anything to do with the liability to decay. In other words, the teeth of persons held to be highly susceptible to decay were just as hard and dense and contained just as much lime salts as the teeth of those not susceptible. It became evident, then, that the active cause of decay is a thing apart from the teeth themselves, and that it acted from without, not being dependent on the condition of the tissues of the teeth but on the condition of the environment. Imperfections such as pits, fissures and bad forms of proximal contact are causes of decay only in the sense of providing opportunity for the action of the processes that induce decay.

In thus establishing the fundamentals which governed the relation of the teeth to the damaging process, a profound influence was exerted on the concept with which the approach to the filling operation was made.

The objects to be attained by filling teeth are, in Black's own words, "to perfect the exclusion of the causes of caries from the tooth tissues by sealing the cavity and securing such form as will prevent lodgments of débris about the margins of fillings, and thus prevent the further action of the cause of caries."

No longer was there any basis for the supposition that some teeth were too soft or too poorly calcified to bear filling with gold or other metal, since it was found that all teeth were abundantly strong. If there was a reason for deferring operations, it was not because of the "softness" of the teeth.

In the extension of cavity margins into territory that was immune, a principle which came to be known as "extension for prevention," another formidable controversy was launched, which receded only after the generous extensions of cavity margins for inlay practice became standard.

In thus laying cavity margins in areas of relative immunity, the filling operation was changed, as Noyes says, "from the simple restoration of lost tissue to a therapeutic measure in the treatment of disease."

There is some degree of contrast between that concept and the mechanical therapeutics of the earlier time, which included Arthur's separation of the teeth and the extraction of molars and bicuspids, practices which were in effect attempts to "remove the tooth from the cause of decay rather than to remove the cause from the tooth."

It seemed equally necessary to Black to include an investigation of the physical character of filling materials. There is opportunity only to refer to his exhaustive study of the physical properties of amalgams; his stabilization of these through standardization of the proportions and properties of their ingredients, and his experiments dealing with the densities to be obtained through the different methods of manipulation of gold foil. Only by reading the detailed description as published at that time can one gain an idea of the exhaustiveness of his work.

But with his recognition of various factors in the decay process, it is of extreme interest at the present time to read that Black realized that all these were not sufficient as a full explanation. The state of science at that time was not sufficient. There still was a missing factor, something that he vaguely incorporated in the physiology of the individual as expressed in the fluids of the mouth.

This, he said, was left for future study to reveal. The science of our own time has received these fundamentals as given by Black, with scarcely an erasure or addition, and his "missing factor" is still a missing factor. It is hopeful to believe that, by the signs in the sky, it cannot much longer remain so.

By 1888, as declared by a forceful writer at that time, it could be said that "dentistry was just stepping into the light of a more exact science." It could be more correctly said that dentistry had advanced a long way into her place in the scientific sun.

The conception of the nature of the decay process had been tremendously clarified, and the practical procedures of restorative dentistry had been brought at least into partial conformity to the newer knowledge. Rationality of concept needed above all else at that time an accurate understanding of the embryologic origin and histologic structure of the tooth tissues, particularly the enamel, in consideration of which we come to the work and achievements of J. Leon Williams.

In certain respects, the work of Williams and Black ran closely parallel, and, curiously enough, Williams knew nothing of the other until he saw it published. This adds the value of an independent investigation.

When Williams had published the result of his study of tooth development, a picture very different from that prevailing was projected.

Here was a young man who had dared to step into the arena and boldly set aside opinions that had all the weight of authority. Small wonder then that he was challenged to defend his doctrines and make clear his strange language. In his acceptance of the challenge, we are ushered into two of the most spectacular debates that dental history chronicles.

The first of these took place at a meeting of the New England Dental Society, in Providence, R. I., Oct. 4, 1883, which Williams attended by invitation as an essayist, his subject being, "Embryology: with Special Reference to the Development of the Teeth and Contiguous Parts." His consternation can be imagined when he learned on arrival that he was to be preceded on the program by Prof. James E. Garretson, who had chosen what was practically the same subject.

To face Garretson, than whom there

have been few more forceful or elequent speakers in dentistry, on a convention floor, and on his own subject, Williams had to be sure of his ground.

In his discussion of Garretson's address, Williams strode to the center of the ring. After a personal tribute to his adversary, he said: "But one must not be blinded by rare personal accomplishments, and my love for truth so far outranks my deference for men, that I say at the outset frankly, but respectfully, that it has never been my lot in any dental convention to listen to such a presentation of misapprehensions and pseudo-philosophic vagaries as was made by the gentleman who addressed you this afternoon."

Proceeding further, he said:

> It has been said that it is in some respects a misfortune for a man to be born before his time. No man has *ever* been born before his time; but the world has never been without a few, who, as Tyndall would say, 'by an intellectual necessity are constantly crossing the boundary of experimental evidence and discerning principles, laws and relationships of matter, which are beyond the ken of ordinary men.' It is in the very nature of things that these men should be misunderstood and misinterpreted; the reward for their labors must come largely from the delight growing out of a desire to investigate and acquire *truth* for its own sake.

In this last sentence, we see the soul of Williams revealed and discover the principle that actuated his life.

For illustrating the appearance of tissues on a microscopic slide, it was necessary to depend on artists' drawings until Williams commenced to utilize the photomicrograph, which enabled him to show the natural relations of the dental tissues to one another without a break in their continuity. In this way and through improved technic in preparation of specimens of tissues were shown the errors of previous teachings and conceptions.

There could be no answer to his exhaustive and scholarly exposition of tooth embryology at the Providence meeting. He having traced the building of the dental tissues, it was evident that the nature of their structure had been erroneously comprehended, and, in his investigation of this, Williams made his outstanding contribution to dental science.

At the seventeenth anniversary meeting of the First District Dental Society of New York, Dec. 9, 1885, occurred the battle of the giants, at which the contenders of the two schools met face to face to defend their views. The essayist was Williams, and his title was "A Critical Essay on the Development and Minute Anatomy of the Teeth in Health and Disease."

Let it be remembered that at that time the Heitzmann theory was well established, and that it had vigorous defenders in the person of its author, and Drs. Abbott and C. F. W. Bödecker. Williams had appraised himself of its structure by spending some time in Heitzmann's laboratory.

In his discussion of Williams' paper, Heitzmann chose the unfortunate method of ridicule, having reference to the youth of the essayist. "One of the peculiarities of genius," he said, "is that it often arrives at truth by methods not dependent on the slower operations of lesser minds." Williams' retort was that "the most logically constructed theory becomes valueless when the premises upon which its first postulates rest are disproved." Dr. Black, who was later to discuss the essay, shaking a warning finger at Heitzmann, advised him to "beware of earnest young men when they got on his track."

The conclusions arrived at in that essay were parallel with the previous conclusions of Black and startling to the same degree. The evidence forced the conclusion that enamel, once completely developed, undergoes no structural change

during life, and probably no molecular change. With devastating logic, he argued the exact and orderly processes of cellular and organic functions: that the material from which enamel is built can be elaborated only through the ameloblasts and in no other way; that enamel is the only tissue of the body the formative organ of which disappears; that the enamel itself is removed from the position of its development and completely isolated from all tissue concerned in its formation, and that this constitutes a uniqueness physiologically that prevents its comparison with any other tissue of the body.

He argued further that the apparently increased or diminished liability of the teeth to decay must be attributed to changes in environment rather than to any inherent change in the enamel itself.

Of particular significance was Williams' demonstration, through his microscopic technic, of the invariable presence of a bacterial plaque covering the location of decay, and he coined the slogan "A clean tooth cannot decay."

Another writer of that period had said, "Formerly everything was clean that we did not know was dirty, but now everything is dirty that we do not know to be microscopically clean."

Could there be any closer approach or clasping of hands as between the theoretical and the practical? The practice of a dentist who believed that enamel may be softened or hardened by the abstraction or restoration of a portion of its mineral substance must be entirely different from that of one who discredits that belief. Certain of the differences in what other observers thought they had seen were explained by the finer adjustments possible in the high grade microscope. Can we not now perceive the tremendous importance inherent in van Leeuwenhoek's discovery!

The close approximation between the positions of Black and Williams on these fundamentals was singularly apparent in Black's discussion of this essay. He sketched the opinions of the previous hundred years down to Robertson, who overthrew the theory of internal decay. "It required 100 years of observation and discussion," he said, "before a man arose who observed sufficiently well to declare that caries did not begin in the dentin." John Tomes, who began with the inflammatory process, did not give it up until he realized its impossibility. The more he studied, the less he found evidence of the vital theory, until he yielded everything.

Black's words in closing his discussion are almost poetic. He said:

> We have had this afternoon a description of the formation of the enamel, and the organ which forms it, and have seen it illustrated by those beautiful photomicrographs. It is formed from within outward, and the organ from which it has derived its nutrition has disappeared. The life-process has built this enamel, laid it down there; and old Dame Nature, life, has stepped backward on tiptoe and gone off and left it, as a good mother would do with her sleeping child for fear of waking it; but, unlike the good mother, has never returned.

Williams had spent a considerable, if not the major part of his professional life in London, whence appeared additional reports of his research and essays on other subjects of a cultural nature.

Some years later, on the occasion of his return for an address before a New York Society, he had expected to meet again his former antagonists, but Prof. Heitzmann had died, and there was from others no further defense of those theories. The triumph of Williams was complete and final, and the subject has never since that time been raised.

The road that we have been following since its emergence from the wilderness has led straight to the temple wherein Science is enthroned, and but for the

plain footsteps of those who had first traversed it, our journey would have been difficult indeed.

Within that temple, their achievements are written large in letters of stone, unerasable and everlasting. To utilize Goethe's words:

**Regretfully we realize that we cannot expect to have others like these straightaway. How could the Deity keep on working miracles if He did not sometimes manifest His might in individuals, at whose extraordinary powers we gaze in wonderment, never realizing whence they are derived.**

**2 East Fifty-Fourth Street.**

# FOUNDATIONS OF MANDIBULAR MOVEMENTS*

By HUGH W. MacMILLAN, D.D.S., M.D., F.A.C.D., Cincinnati, Ohio

THE development of the mouth began in Archeozoic times when the first ameba-like protozoan captured and held with its pseudopodia a microscopic morsel of food until digestion had taken place. Throughout the ages, more complicated patterns of mouths developed, until now, in Psychozoic times, the analysis of the mandibular movements in man is such a complicated and intricate problem as to be almost unsolvable. By tracing the development of the mouth through fossil remains of extinct animals and by comparison of living animals representing successive steps in the development of the vertebrates, the explanation of many problems concerned with mandibular movement, such as unilateral mastication and unilateral balance, may be made somewhat clearer.

One of the most primitive types of mouth is found in Amphioxus, a small transparent animal about 2 inches long which may be best described as a headless fish. The mouth is a longitudinal fissure having no jaws and surrounded by a number of labial cartilages. The animal burrows in the sand leaving only its mouth exposed and feeds on diatoms which are directed into its mouth by the current of water passing through its gill slits. Located in the primitive pharynx is a ventral groove secreting a viscous fluid which engages the food. Lining this groove are cilia which propel the food into the intestine.

The cyclostomata are eellike marine animals with cartilaginous skulls without jaws. Similar to leeches, they have round suctorial mouths. The mouth or oral hood is supported by an annular cartilage and equipped with horny, epidermic teeth.[1]

Both in Amphioxus and Cyclostomata, there are no jaws, the mouth being open at all times.

In Proterozoic time, the original mouth was derived from some invertebrate form. Patten claims the vertebrates evolved through the arachnid stem.[2] The ostracoderm has been called the missing link between the vertebrates and invertebrates. In the Silurian ostracoderm, Trematapsis, the mouth slit is parallel to the long axis of the body. The primitive

1. Wilder, H. H.: History of the Human Body, Ed. 2, New York: Henry Holt & Co., 1923, p. 296.

2. Patten, William: Foundations of the Face, Scientific Month., December, 1932, p. 511.

jaws work from side to side or toward the midline as in Limulus. In the Devonian ostracoderm, Bothriolepis, the mouth has changed to a position at right angles to the long axis and occupies a transverse position similar to that of the higher vertebrates. In a reconstruction of Bothriolepis, Patten shows the maxillary and mandibular processes to have developed from the mandibular arch as in the true vertebrates except that the processes have failed to meet by a considerable space at the median line.[2] Hence, these animals chewed their food unilaterally, the right upper jaw being separated from the left upper jaw, and the right lower jaw, from the left lower jaw except for folds of skin forming primitive "lips." The theory

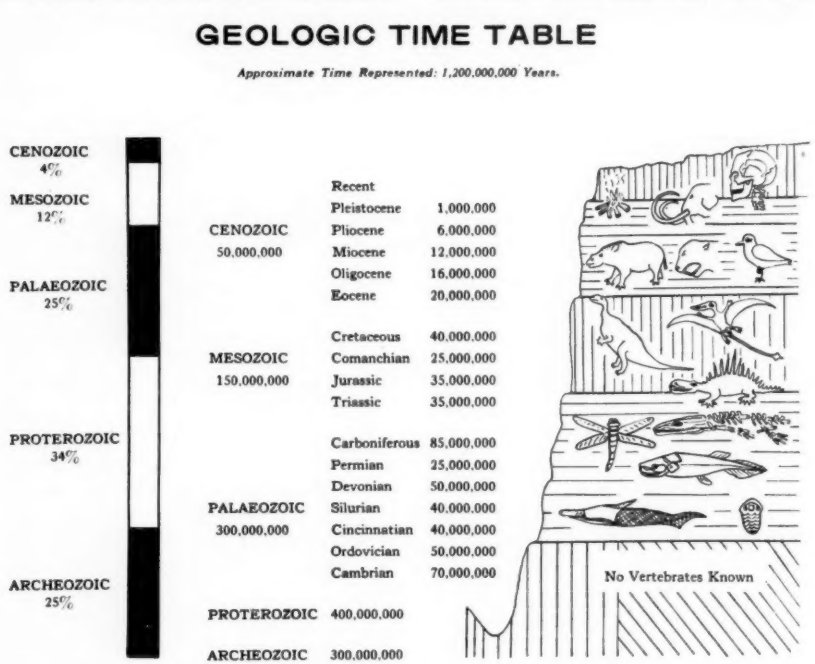



Fig. 1.—Illustrated geologic time table with an estimate of time in years, adapted from Schuchert, Le Conte, Dana, Loomis, Gregory and Osborn. At the right is shown an ideal section illustrating the four rock systems of early geologic science with outline drawings of animals, the fossils of which are found in the corresponding rocks. The uppermost vertically lined division represents the quaternary rock system; the next below, horizontally lined, the tertiary system. These two rock systems contain the fossils of Cenozoic time. The next division, vertically lined, is the secondary rock system containing fossils of Mesozoic time. Below the secondary rocks is the sometimes called transition rock system containing fossils of Palaeozoic time; and finally is shown earth's oldest rocks, the primary or primitive system comprising the Archeozoic and Proterozoic rocks containing in their upper strata evidence of "protophytic and protozoic life." The chart represents general facts in the progress of the life development of the vertebrates. An ostracoderm is represented as the fishlike animal at the beginning of the Palaeozoic era.

of bilateral balance and three point contact was not conceived until 500,000,000 years later.

The most primitive group of Gnathostomata are the selachians, which comprise the sharks, dog fish and skates. The skeleton is entirely cartilaginous. The upper and lower jaws are known as the palatoquadrate and Meckel's cartilage, respectively. The dorsal half of the hyoid arch, the hyomandibular arch or suspensorium, forms an attachment between the cranium and the upper jaw and assists in the formation of a joint between the upper and lower jaw.

**In selachians the jaws are equipped with several rows of pointed teeth, usually arranged like the scales which cover the surface, and as the lining of the mouth cavity has exactly the same embryonic history as the external skin and is composed of the same two layers, it must be concluded that the teeth were once simple placoid scales like the rest, and that their later modifications have been due to the difference of the function to which they have become subjected, an inference sufficient to account for their slight changes in form as well as for their increased size and hardness, which is correlated with the greater amount of work to be accomplished. These organs, when once acquired, are subjected to great variations as an accommodation for the prehension and mastication of the innumerable kinds of food; they develop as pointed needles, fangs for inoculating poison, sharp-edged chisels, flat surfaces for grinding, and ornamental tusks, in all retaining the general structure characteristic of placoid scales.**[3]

The muscles of mastication in the mammals may be traced directly to the muscles regulating the gill arches of the selachians. These gill arch muscles are described by Wilder as "levators, depressors, constrictors, dilators."[4] From the first branchiomere, supplied by the fifth nerve, is derived the primitive temporal and masseter. From the second or hyoid branchiomere, supplied by the seventh nerve, is derived the posterior belly of the digastric, which becomes attached to the posterior surface of the primitive mandible in such a way that it opens the mouth. These muscles continue with little change through the higher vertebrates.

The next great advance in the development of the framework of the jaws occurred in the Ganoidea of Paleozoic time. They were characterized externally by horny plates covered with enamel and angular shiny scales forming an integumentary skeleton. At this stage of vertebrate history, the cartilaginous lower jaw became completely encased by dermal bones and the original upper jaw was superseded by the premaxillary, maxillary, palatine and pterygoid bones, which developed from the skin around it. The posterior part of the upper jaw came to fit in between the hyomandibular and the articulare of the lower jaw as an extra suspensory piece, becoming eventually the quadrate.[5]

The Amphibia are the connecting link between the air-breathing and the water-breathing forms. The first four-legged vertebrates appeared in the Devonian period. The transition from water to land produced or was associated with the greatest change that had so far appeared in the history of the vertebrates. The development of the lungs changed the entire structure of the upper air passages. Two openings, posterior nares or choanae, appeared in the roof of the mouth, connecting it with the nasal cavities. In the frog, the air is drawn into the mouth through the nostrils and forced into the lungs by the muscles of the throat, as there are no ribs.

In order to keep the nasal and oral passages moist at all times, distinctive glands appeared. In the frog, the intermaxillary glands have assumed a special

3. Footnote 1, p. 83.

4. Footnote 1, p. 273.

5. Footnote 1, p. 175.

function, that of secreting a viscous fluid by means of which the tongue is rendered adhesive for the apprehension of insects.[6] The tongue is attached at its anterior extremity and may be protruded almost its entire length in capturing prey. In the skull, there is a closer fusion of the upper jaw with the cranium. "The membrane bones in existing amphibia have separated from the integument and have sunk to a deeper position than in fishes. The lower jaw also has a reduced number of bones, there being at the most five."[7] As a cartilage bone, the quadrate persists in amphibia, reptilia and birds. The hyo-

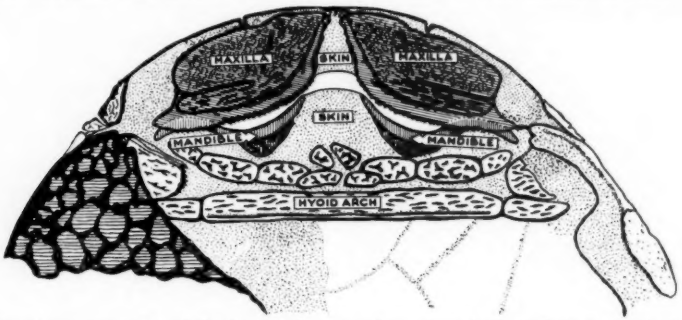



Fig. 2.—A reconstruction of the face of the Devonian ostracoderm Bothriolepis (adapted from Patten). The upper and lower jaws of the right side are separated from the upper and lower jaws of the left side by a considerable interval, the ends being joined only by skin. Each side necessarily operated independently of the opposite side, one side probably remaining at rest during the functional excursions of the opposite working side.

mandibular disappears from the articulation of the mandible and is thought to enter in the formation of the stapes.[8] In the amphibia, the muscles of mastication undergo considerable differentiation.[9]

The Mesozoic era is known as the age of reptiles. A reptile may be defined as a cold-blooded vertebrate breathing by lungs and having a single occipital condyle. The earliest fossils of reptiles are found in the Permian age. They reached their greatest development in Jurassic and Cretaceous times, when they attained gigantic proportions and ruled land, sea and even the air. The skeleton is completely ossified. The skull is small, loosely united, and very different from the amphibians owing to a reduction and disappearance of bones appearing in the more primitive types. In all except the Squamata, the quadrate is firmly fused to the cranium.[10] The mouth is usually provided with conical teeth adapted for seizing and holding prey. The teeth are numerous and fused to the bones bearing them. Like those of the fishes, they are successional.

"In the lower vertebrates the roof of the skull is continuous, its only openings being for those of the nares and the orbits. In the higher groups vacuities or fossae appear into the posterolateral parts, these being bounded by bars or arcades of bone."[11]

6. Footnote 1, p. 314.

7. Kingsley, J. S.: Outlines of Comparative Anatomy of Vertebrates, Ed. 3 (revised), Philadelphia: P. Blakiston's Son & Co., 1926, p. 91.

8. Footnote 1, p. 177.

9. Footnote 7, p. 144.

10. Footnote 7, p. 96.

11. Footnote 7, p. 78.

"The bony tract below the temporal opening distinctly prophesied the mammalian zygomatic arch, the cheek bone of man."[12]

The mammalia, a class of animals whose females have milk secreting mammae to nourish their young, embrace man, all warm-blooded quadrupeds, bats, seals, cetaceans and sirenians. The occipital bone articulates with the atlas by two condyles. The brain reaches its highest development in the mammals. The body is generally covered with hair. The lower jaw articulates directly with the cranium.

Briefly, the history of the various parts entering into the structure of the mammalian mouth is as follows:

First, as to the jaws: the longitudinal mouth slit of Trematapsis, the transverse position of Bothriolepsis, the cartilaginous jaws of the selachians, the formation of the dermal jaw bones in the ganoidea, the sinking of the dermal bones in the amphibia, the reduction of the dermal elements in the reptilia, the mandible in the mammalia consisting "solely of the two dentary bones (one on each side) connected at the front end, or symphysis."[13]

As to the joint between the jaws: the hyomandibular arch or suspensorium assisting in forming the joint in the selachians, the addition of the quadrate to the joint in the ganoidea, the disappearance of the hyomandibular arch in the amphibia, the specialized development of the quadrate in the reptilia, the disappearance of the quadrate to form part of the middle ear and the formation of a ginglymo-arthrodial joint between the dentary and the squamosal in the mammalia.

The nasal fossa: beginning as a median ciliated pit in amphioxus, the nasal sacs in fishes and the amphibia, the formation of the hard palate in the mammal-like reptilia, and eventually the separation of nasopharynx and pharynx by the soft palate in the mammalia.

The teeth: sharp conical teeth adapted for seizing and holding prey in the lower vertebrates; teeth differentiated into incisors, canines, bicuspids and molars in the herbivora and omnivora.

The direction of mandibular excursion: from the vertical excursions of the lower vertebrates to the sweeping transverse excursions of the mandibular molars across the crowns of the maxillary molars in the herbivora and to a lesser extent in man. This movement is reversed when the bolus is transferred to the opposite side.

As to food: ostracoderms, fern and shell fish; fish, smaller fish, crustacea, insects, worms; amphibia, worms, slugs, insects; reptilia, worms, eggs, insects, birds, fish, amphibia and mammalia; mammalia, fish, flesh, grasses, grains, fruits, insects and various combinations.

The tongue: fishes, no functional tongue; cyclostomata, "with its terminal armament of epidermal teeth it serves as a boring organ with which the mixinoids obtain entrance into their prey, while in the lampreys it serves as a rasping organ and also as part of the sucking apparatus"[14]; amphibia, tongue, in some forms is so fixed at the front of the mouth that the free end turns backward; reptilia, tongue sometimes unusually long, being retracted in sheaths running down the sides of the body; mammalia, fleshy tongue developed upon the dorsal side of the reptilian tongue, composed of interlacing intrinsic and extrinsic muscles.

With the great geologic changes oc-

12. Gregory, W. K.: From Fish to Man, New York: G. P. Putnam's Sons, 1929, p. 34.

13. Footnote 12, p. 36.

14. Footnote 7, p. 232.

curring in the Jurassic period, the climate became cool and climatic zones were accentuated. In the mountains of Colorado are the records of glaciers. "The drop in temperature was enough to change the flora of the flowering plants, and there arose in the open plains more and more grasses and cereals. The Cretaceous inland swamps were now all blotted out and with their disappearance and the changed flora the highly specialized dinosaurs, pterodactyls, toothed birds and marine reptiles vanished. The sun shown on a new era, the Cenozoic."[15]

In the rocks of the Permian period are found fossils of the first mammals or mammal-like reptiles. These animals were of the size of the modern rat and at first laid eggs as the reptiles. During their later development in the Cretaceous period, they become as large as sheep, with short limbs, long and heavy tails and small brains. For millions of years, they continued to develop in spite of a world swarming with carnivorous reptiles. Probably the one physical attribute that made possible their existence was sufficient speed to escape from their carnivorous enemies. Speed called for more oxygen and oxygen can be taken to the tissues only by the blood stream. As a result, the heart and circulatory system were so altered that the blood was aerated and distributed more efficiently. Developed at the same time was a system of forced ventilation. As swallowed air could no longer suffice, a muscular diaphragm appeared. The animal became warm blooded. To retain the bodily heat as a protection from the increasing cold, fur or hair developed as an insulating covering.

The advent of grasses and cereals produced the greatest change in the jaws that had occurred since the days of Trematapis and Bothriolepis. The muscles of mastication were derived, as has been stated, from the muscles activating the gill arches in the predecessors of the fishes. Simplified in the amphibia, their specialization appears in the reptilia with the appearance of the temporal fossa. Probably, the disappearance of bone over that part of the skull covering the temporal muscle was due to disuse resulting from a change in the direction of the pull of the muscle fibers. The beginning of lateral movement, which seems to be coincident with the appearance of this new kind of food, resulted in the formation of the zygomatic arcade for attachment of the masseter and the strengthening of the pterygoid processes for the internal pterygoid.

The movement of the jaw in the herbivorous mammalia became a transverse sweeping motion in order to break up more efficiently the carbohydrate foodstuffs for the action of the ptyalin, which first appears at this time. Instead of continuing chiefly as a trap for the capture of food, the mouth now becomes a factor in its digestion.

The articulation of the dentary directly with the cranium, the development of the rounded condylar process, and the formation of the meniscus derived, according to Gaupp,[16] from the external pterygoid muscle, released the jaw for the ectal, ental, proal, palinal and other movements.

Four other momentous changes take place in the mouth of mammals: first, the development of the fleshy muscular folds about the mouth—the lips; second, the appearance of the buccinator muscle; third, the formation of a new tongue over the framework of the reptilian

15. Schukert, Charles, and Levene, Clara M.: Earth and Its Rhythms, New York: D. Appleton and Co., 1927, p. 300.

16. Footnote 12, p. 38.

tongue, and fourth, the separation of the nasal cavity from the oral cavity by the soft palate. Derived from the primitive sphincter colli of the reptiles, the platysma muscles grow forward over the face interlacing around the rima oris as a sphincter of no small importance in suckling and confining the food anteriorly. Derived from the same muscular sheet, the buccinator seems to have developed for the express purpose of confining the food between the grinding surfaces of the molars from the cheek side. The intrinsic muscle mass characterizing the mammalian tongue seems to have developed primarily for the purpose of confining the food between the grinding surfaces of the teeth from the lingual side. Without the hermetically sealed partition formed by the soft palate, there would be no suckling, no mammalia.

Unilateral mastication and the reversal of the masticatory excursion began with the transverse swing of the mandible in those animals adopting the frugivorous and herbivorous diet. "When chewing is performed on the right side (in man), the excursive movement across the antagonizing surfaces is from right to left. When chewing is done on the left side, the movement is reversed. The muscles of mastication of one side are designed to move the mandible in a direction opposite to that produced by the muscles of the other side."[17]

In comparing the dentition of the camel with that of the pecora, Todd observes "the relative narrowness of the mandible compared with the breadth of the palate." He continues: "In consequence the upper and lower cheek teeth of one side only can enter into contact at one time; on the opposite side of the upper cheek teeth project so far beyond those of the lower jaw that there can be no occlusion."[18]

Since mastication can occur only unilaterally in many animals owing to the inability of the opposite dental series to come in contact, and since normal mastication can occur only unilaterally in man owing, among other things, to the reversal of the masticatory excursion, the terms "bilateral balance" and "three-point contact" should be discarded as not accurately descriptive of the mechanics of the muscles which prevent the mandible from "tipping." Mandibular equilibrium is maintained at all times by the coordination of the muscles, chiefly of the working side, without the "aid of the articulating molars on the opposite side of the mouth."

To recapitulate: The inclusion of carbohydrate food required a molar of a grinding type, a rotary movement of the jaw, a rounded condylar process, a new type of tongue, cheek, lips and palate, a specialization of the muscles of mastication to the orthal, ectal, ental, proal or palinal type of excursion, the production of the unilateral chewing mechanism, and the maintenance of mandibular equilibrium chiefly by the muscles of the working side.

The anatomic mechanisms concerned in mastication portray the culmination of development for a thousand million years.

1005 Union Central Life Building.

17. MacMillan, H. W.: Unilateral Vs. Bilateral Balanced Occlusion, J.A.D.A., 17:1217 (July) 1930.

18. Todd, T. W.: Introduction to Mammalian Dentition, St. Louis: C. V. Mosby Company, 1918, p. 206.

# IMMEDIATE DENTURE SERVICE*

By DAYTON D. CAMPBELL, D.D.S., Kansas City, Mo.

CONSTRUCTION prior to the loss of all the natural teeth of artificial dentures ready to be placed in the mouth immediately is as old a procedure as the history of vulcanite. No doubt, the first dentist to construct a denture of this character was prompted in his effort by the insistent demand of the patient for something that would permit him to appear in public and escape the jests and jibes of friends and foes. I describe a satisfactory method of constructing immediate dentures in my textbook, "Full Denture Prosthesis." Since the introduction of gelatinous impression materials, Sidney S. Jaffee, of Washington, D. C., has given us a most satisfactory technic. His justification for the use of immediate dentures is flawless, and I, with certain minor changes in the modus operandi, subscribe to the method.

There are occasions when the immediate denture is not sufficiently immediate. The occasion may be rare: The patient, impatient and leaving town, the physician orders the teeth out immediately (time element). Without having seen the patient previous to presentation, the technic to be developed in this article may be used to construct an immediate denture. This technic, after a little experience, consumes less than an hour and provides a denture for a period of from ten to thirty days that is comfortable and remarkably natural in appearance. This interval of from one to four weeks is conducive of better results with the dentures that are to follow, and certain it is that the lips do not present any undue fulness where surgical interference has intervened. Several years ago, I became obsessed with the idea that the surgeon's sutures produced a row of cicatricial spots that were anything but an aid to the comfort of the patient and retention of the subsequent dentures. A modeling compound impression of the palatal portion of the ridge was so taken that the crest of the ridge was forced buccally and labially. Compound was then traced on the buccal and labial borders of the same tray and these tissues were directed toward the crest of the ridge. Subsequently, the fear of scar tissue proved unfounded, but the splint became a necessity. A baseplate splint was constructed on a cast, and poured into this impression. Biteblocks were added with the modeling compound to support the dangling jaw. The mother of invention supplied a tougher, stronger, more esthetic material for these blocks in Dennison sealing wax, No. 231, which, in turn, could be used to attach crowns and bridges, cleaned up from the wreck, the net result being a satisfactory denture that is truly immediate in every sense of the word.

The term "immediate denture" is meant to imply a denture that is inserted in the patient's mouth immediately on removal of the natural teeth. It is in-

*Read at the Seventy-Fifth Annual Session of the American Dental Association in conjunction with the Chicago Centennial Congress, Aug. 10, 1933.

tended to bridge the gap between the extraction of the natural teeth and the insertion of the temporary dentures.

The advantages to be gained by this type of work are numerous, both to the patient and to the dentist. The particular advantage is from the point of view of esthetics; for we are able to supply the patients immediately with some substitute for the natural teeth and thereby to eliminate the necessity of their being seen without teeth or having to hide themselves from the public eye.

Among other advantages to be gained is the prevention of changes in the facial contour that may possibly cause some difficulty in restoring to the normal. The immediate denture also forms a rest for the mandible, and a splint or bandage for protection of the tissues, and prevents

Fig. 1.—Appearance of patient before and after removal of teeth and insertion of immediate denture.

Fig. 2.—Smiling view of patient shown in Figure 1, before and after removal of teeth and insertion of immediate denture.

food and other foreign materials from entering the sockets. This denture prevents the patient from massaging the tissue with the tongue and forcefully creating a vacuum in an effort to remove physiologic blood clots. The technic, which involves a negligible amount of time and materials and is quite simple, is as follows: By the way of preliminary work and before the teeth are removed, the particular individual facial characteristics and their relation to the teeth are noted. While I subscribe to the use of dimensional measuring devices, profile cards, face masks, etc., their greatest field of usefulness is in spectacular clinics and as psychologic adjuncts. A greater need is a healthy conscience, good roentgenograms and an oral surgeon that is truly desirous of a favorable result. With the teeth closed in centric relation, softened modeling compound is pressed around the labial surfaces of the upper and lower anterior teeth. The compound, when hard, is removed, and, at some convenient time, a plaster cast is poured into it. This produces a replica of the form and alinement of the teeth and subsequently serves as a model to help in the arrangement of the porcelain substitutes. It is especially valuable in maintaining the proper overjet. The overbite is not a factor, since, in this improvised denture, the anterior teeth will not touch. Such contacts are inimicable to good retention.

Porcelain teeth are selected and modified to simulate the natural teeth, the operator staining, etching and reproducing gold fillings with the ceramist's gold paint. The artist dentist is, in fact, limited only by his capabilities. Selecting an extra cuspid or two for each side to take the place of the bicuspids is often advisable.

After the teeth are extracted, and such sharp points of process and protuberances are reduced as might interfere with the retention of any denture, a good modeling compound impression is secured. The required "muscle trimming" is done with a sharp knife, and, at this time, all of the impressions of the tooth sockets are removed, the operator smoothing up the impression of the crest portion of the ridge until it presents an ideal appearance. This is of the utmost importance, since the character of the ridge for future bases is molded in a replica of this intaglio, and a plaster cast is poured approximately as thick as it is wide. When the cast is poured to this thickness, it presents approximately a cube, which is the strongest form of a solid. While nothing is to be swaged on this cast, the additional support which this thickness lends to the cast gives it sufficient strength that it may be used the mini-

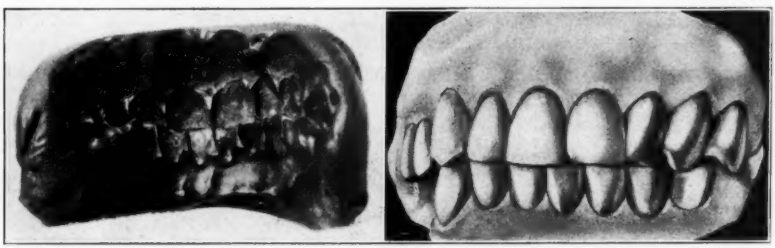


Fig. 3.—Impression and cast of anterior teeth, cast to be used as model in setting up porcelain teeth.

mum length of time. Warm water and potassium sulphate, vigorously spatulated, are employed to accelerate plaster setting. The cast, after its initial set, is immersed in a pan of hot water and removed from the impression. An application of a little soap-stone or talcum powder, and it is ready to use.

A pink baseplate compound such as is used in the construction of occlusion models is now adapted to the cast. While any rigid baseplate material may be used, the pink is more satisfactory to the patient and does not tend to disintegrate as some of the shellac compounds will after they have been in the mouth for a few days. The baseplate material is accurately adapted. The periphery is *not* trimmed with a pair of scissors, but instead is heated with a flame directed by a chip blower or mouth blowpipe and folded back upon itself. The advantage of this method of finishing the border is threefold: 1. It facilitates rapid adaptation. 2. It provides a smooth rounded border that does not require polishing. 3. It affords additional strength.

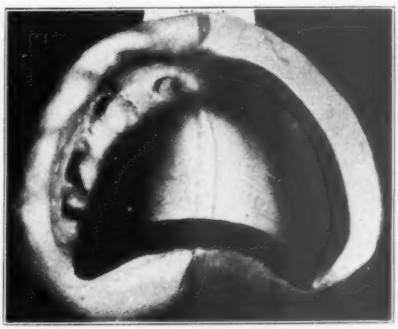


Fig. 4.—Impression showing intaglio. The right portion is trimmed to form an ideal matrix for the subsequent ridge.

The baseplate is now removed from the cast and laid aside. A sheet of 30-gage aluminum is cut to the approximate shape and size of the palate and annealed in an open flame until the surface presents a stippled appearance, then is allowed to cool. The aluminum is now quite soft and is readily adapted roughly to the palatal portion of the cast with the fingers and the wooden handle of a laboratory instrument.

This adaptation need not be perfect, and if the aluminum should wrinkle or split slightly, it is of small import. The aluminum is removed from the cast and the adapted baseplate returned to position. This aluminum strengthener is heated, and as it sears itself in position on the baseplate, is pressed down with the thumb protected with a towel.

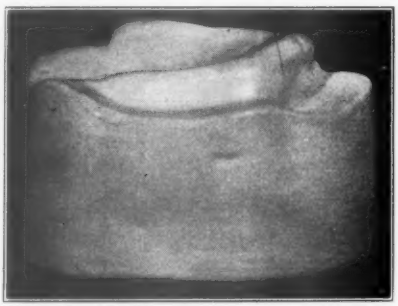


Fig. 5.—Plaster cast approximately as thick as it is wide.

A stick of Dennison sealing wax No. 231, is heated over the flame and is traced along the ridge portion of the baseplate to make sure that the superstructure will be attached securely. A piece of this wax, about an inch or so long, is broken from the stick and sealed on the bicuspid and molar region of the base; one piece on each side. With this sealing wax securely attached and softened somewhat, the base is placed in the patient's mouth and he is asked to close against this softened wax. This is to determine the interval between the mandible and maxilla, or the

vertical dimension. No particular attempt is made at this time to secure an accurate centric relation. Since the last time the patient's own teeth were closed in centric relation, no extraneous movements of the jaw have developed and it is interesting to note that they do close in centric relation.

On returning to the laboratory, the operator carefully removes the carding wax from the pins of the previously selected artificial teeth and applies a small portion of this sealing wax to the pins, and casts it securely around them with pressure from the thumb. The teeth are now set up on the reinforced baseplate with Dennison sealing wax in

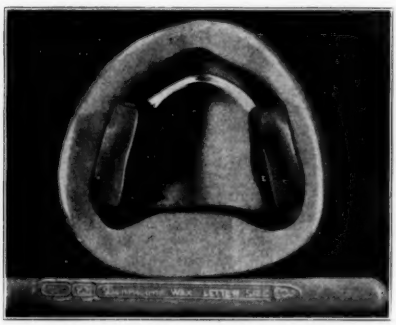


Fig. 6.—Occlusion model. The palatal portion is strengthened with 30-gage aluminum plate. Dennison wax blocks are securely attached.

exactly the same manner as though they were being set up in ordinary baseplate wax.

The plaster cast of the labial surface of the anterior teeth is used as a guide in arranging the artificial teeth. The case is now returned to the patient's mouth, and if any adjustment is found to be necessary in the arrangement of these teeth, it may easily be accomplished by removing the case and softening the wax with a flame directed against the particular spot by a chip blower or mouth blowpipe. The surface of the wax or tooth is allowed to cool for a moment so that it will not burn the patient's lips. The wax adjacent to the ridge lap portion of the tooth is still soft and may be moved easily. It is returned to the mouth and the operator has a moment or two to vary the arrangement before the wax becomes too rigid for further manipulation. The case is now completed.

In the view of the patient, one of the commercial adhesive powders is sprinkled quite generously in the intaglio, or tissue side of the denture, which is then inserted.

The patient is instructed to wear the denture throughout the remainder of the day and through the night, but to remove it in the morning and wash it carefully in cold water. Further instructions request a generous use of the powder to retain the denture. Patently, the instructions to use the powder, which is provided, are purely psychologic; for it is desirable to have the patient return to the office in a few days triumphant over the fact that he did not have to use the powder to retain the denture.

Fig. 7.—Labial view of technic case.

Unless earlier examination is deemed advisable, the patient is instructed to return to the office in eight or ten days for examination of the mouth. It is amazing to note the condition of the tissues in comparison to a mouth that has had no treatment of this type.

At this time, the impression is taken for the temporary denture, and the case is run through in the customary manner, the patient wearing the immediate dentures in the interim. When the denture is completed, the transition is so satisfactory that the chain of keeping the patient supplied with teeth continuously is not broken. It may be noticed that these immediate dentures are rather thick, bulky and heavy. This, psychologically, is a decided advantage, for the patient has been reasonably comfortable with these thick "old shoes," and when we remove them and in their place insert a thin, polished, well-finished denture, he has the same feeling that one would experience if he had worn rubber boots all day, and, come home at night, had put on his

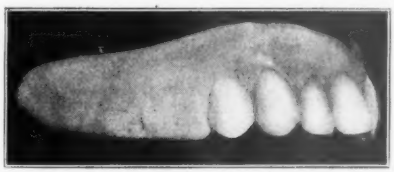


Fig. 8.—Buccal view of technic case.

house slippers. He feels as though he were floating on air for a few steps, and it is felt that if the patient can be made to float on air for a few steps with the new masticating mechanism, something has been accomplished.

Frequently, the question may arise in the patient's mind as to the ability to wear any kind of a denture over the injured gum tissue, and often the question is put to us: "Doctor, won't these plates hurt my sore gums?" Our answer is, "Yes, these dentures will hurt your sore gums in the same proportion that a bandage or splint will an injured finger." The new denture may not feel so comfortable, but the patient will experience greater comfort with the denture than without it, and it is gratifying to find that the patient is usually the most enthusiastic person concerned.

As far as the technic is concerned, the lower denture is constructed in the same manner as the upper, with but one exception: a flattened wire strengthener is used instead of the sheet aluminum. Ordinarily, in constructing an upper and a lower denture, it is found to be the best practice to remove the upper remaining teeth and construct the upper immediate denture; then, if, after a period of two or three days, there is no unfavorable reaction, construct the lower denture to occlude with the upper. The patient is not

Fig. 9.—Palatal view of practical case shown in Figures 1-2 (right).

encouraged to masticate with these dentures, but he does deserve a delightful surprise when you are informed of his first favorable effort. He should keep the dentures in position at all times except when they are removed for cleaning.

Any food or liquid that may comfortably pass the lips and tongue will not be hot enough to soften the wax, which will be found very satisfactory in retaining the teeth on the base because the tissue will not tolerate much pressure. Gradually the tissue heals, gradually masticatory stress increases, and gradu-

ally the teeth begin to come off. This period varies with different conditions and different patients, but it is a true indicator of their entry into the field of artificial denture wearers.

Now that this denture has been constructed and the patient has worn it for several days and received the regular vulcanized denture, we may look back and note the advantages gained by this technic. This denture has:

1. Acted as a rest for the mandible.
2. Held the lips and cheeks in their proper relation.
3. Given a proper form to the blood clot.
4. Been a protection to the soft tissues within and without the sockets of the extracted teeth.

Fig. 10.—Labial view of case shown in Figure 9.

5. Acted to prevent the development of extraneous movements of the mandible.
6. Maintained the facial outlines.
7. Prevented disturbances in the region of the glenoid fossa.
8. Been an aid to the general comfort of the patient.
9. Acted to reestablish confidence in the patient after the depressing thought of losing the teeth.
10. Prevented the shortening of the vertical dimension.
11. Accustomed the patient to a foreign object in the mouth.
12. Aided the patient in becoming accustomed to the new denture.

The benefits to be derived from this immediate denture service are not temporary; for while effecting a satisfactory transition from nature's disrupted plan to an artificial chewing mechanism, the encomiums heaped upon the operator are helpful in practice building.

## SUMMARY

Before the removal of the teeth:

1. Take an impression of the labial surfaces of the anterior teeth with the teeth closed in centric occlusion.
2. Note the appearance, mold and shade of the natural teeth.
3. Select the artificial anterior teeth.
4. Remove the carding wax from the pins and place sealing wax around these pins.
5. Secure 30-gage sheet aluminum and anneal.

After removal of the teeth:

1. Take a modeling compound impression, postdam and trim correctly, removing all impressions of the tooth sockets.
2. Pour thick plaster cast.
3. Adapt baseplate compound; remove.
4. Adapt annealed aluminum.
5. Replace baseplate material and seal aluminum strengthener in place.
6. Add blocks of sealing wax in the posterior region.
7. Return to the patient's mouth and determine the interval between the mandible and the maxilla.
8. Return to the laboratory and attach the anterior teeth with sealing wax as a guide.
9. Take it to the patient's mouth and make necessary adjustments

The case is now completed and ready for insertion.

# VALUE OF IMMEDIATE FULL RESTORATION AND PREEXTRACTION RECORDS*

By SIDNEY S. JAFFE, D.D.S., Washington, D. C.

SCIENTIFIC progress in dentistry, as every practitioner who has delved into problems beyond our immediate knowledge well realizes, is the residue of a series of trials and errors. This being true, it seems to me that our cumulative professional knowledge will increase only in proportion to the rate at which the little residue of truth that each of us gains is distributed among us. Hence, the purpose of this paper is to set forth the results of many years of experience and practice in the field of prosthetic dentistry, which has led me to two prime conclusions:

1. The immediate full restoration of teeth presents so many advantages, from the standpoint of both the patient and the dentist, that it should become a universal practice.

2. The taking of accurate preextraction records is so urgent a necessity in the practice of full denture prosthesis that it should become an elementary rule of the profession.

Let us consider the two matters separately, although they are interrelated to the extent that an accurate preextraction record is essential to the immediate replacement of dentures.

## IMMEDIATE FULL RESTORATION

By immediate full restoration, I mean simply the extraction of the patient's teeth and their replacement by artificial dentures during the same sitting in the dentist's chair. In merely defining the term, I realize that I break sharply with the widespread belief that a person must go many weeks or even months edentulous before restoration can be attempted. Yet I am convinced that only ignorance of the general public has let this belief go unchallenged. Furthermore, I am confident that if the advantages of immediate restoration were fully understood by the profession, many dentists would adopt this technic. Let us consider the advantages of immediate dentures from the standpoint of:

*1. The Patient.*—The edentulous period, lasting sometimes as long as three months under the dictates of established practice, is one of acute suffering, both physical and mental, for the average man or woman.

Having lost his natural teeth and having no substitutes, the patient soon finds the mandible is virtually in a dislocated position. Thus, the whole appearance of the face is changed. The patient feels strange and unnatural. He dislikes to meet his friends. One cannot help noticing the aged, unnatural appearance of the person who has gone edentulous even for a short time.

As though this condition were not enough, the toothless patient finds it very difficult to enunciate clearly. Even when restoration is made later, it is likely that

*Read at the Seventy-Fifth Annual Session of the American Dental Association in conjunction with the Chicago Centennial Dental Congress, Aug. 10, 1933.

the natural lingual relationship between tongue and teeth cannot be exactly duplicated and the patient must learn to enunciate anew.

When immediate restoration is made, and absolute accuracy of replacement is assured by means of the lingual matrix (which I shall describe later), these trials are abolished. The patient, having had his original teeth extracted, has them replaced immediately by artificial duplicates. As he is never seen, either by himself or his friends, in an edentulous condition, he avoids embarrassment and resulting morbidity. Further, as the artificial dentures are a replica of the original teeth, and as the correct lingual relationship between tongue and teeth is preserved, the patient finds no difficulty in getting used to them in a very short time. In fact, he feels comfortable.

*2. The Dentist.*—The advantages of immediate replacement from the standpoint of the dentist are no less marked. His prime purpose, of course, is to extract the original teeth and replace them with satisfactory artificial dentures with a maximum of efficiency and a minimum of trouble for himself and of suffering for the patient. The successful outcome of the dentist's effort is promoted because the patient will be constrained not to remove the dentures, even for a short period, as his friends have never seen him edentulous, and he does not want them to do so.

When immediate restoration is practiced, postoperative pain is reduced. The dentures act as a splint or bandage. They are fitted immediately after extraction and thus protect the alveoli against trauma and infection.

Immediate replacement, furthermore, halts postoperative bleeding. Cases of excessive bleeding cause worry to all of us. Usually we attempt to stop loss of blood by using a compress, but it is not convenient to hold one long enough for it to be effective. In fact, it is difficult to stop bleeding at all by this means, in an edentulous condition. A denture, immediately placed, fits over the bleeding area, acts as a bandage and helps to support the blood clot.

Immediate dentures supply proper occlusual rests and thus help to maintain the proper intermaxillary relationship. Therefore, there is little change in the temporomandibular joint, and the patient does not suffer muscle fatigue, impaired hearing or similar ills. The muscles of mastication function as usual and the habitual functional paths are kept intact.

The alveolar process is conserved by immediate dentures. This is true because the alveolar ridge does not absorb so readily as when replacement is delayed. Rather, it develops into a more favorable base. The denture affords comfort to the patient by supplying a slight, uniform pressure on the alveolar ridge; and while long periods of sustained pressure would cause absorption of the bony base, intermittent pressure accelerates calcification.

Finally, with immediate replacement, functional centric relationship can be more easily established.

## LOOKING BACKWARD

With these advantages of immediate replacement so obvious, why is this practice not more widespread? The answer, I think, is simple. Until recently—say ten or fifteen years ago—the dental profession as a whole showed but little interest in advanced full denture work, and the methods of practicing it were incompetent. For example, impression technic was faulty, balanced articulation was not understood and there was no thoroughly reliable method of taking preextraction records. Now, with the modern precision technic, there is no reason that every dentist should not practice im-

mediate full denture work, and save himself and the patient much worry and disappointment.

The last point—the taking of accurate preextraction records—is so important in the field of full denture prosthesis that I should like to discuss it at some length. It is the basic point in my technic of immediate full restoration, which I shall outline later.

## PREEXTRACTION RECORDS

Perhaps the practitioner of full denture work is too prone to forget that the satisfaction of his patient depends largely on one thing: the extent to which the dentist preserves the patient's natural facial appearance and his facility of enunciation without a trying period of readjustment. Of course, the patient is concerned with masticatory comfort, but only secondarily to esthetics. If the patient is happy about his appearance after the insertion of dentures, his mental attitude will be a great help to him in learning to master the details of their use. Every dentist has learned from experience the impossibility of getting cooperation from a discriminating patient who has dentures that do not look well.

The realization of all of these aims, it appears to me, depends on the precise reproduction of the natural teeth and the maintenance of their cranial relationship; and more and more dentists are coming to realize that these ends can be achieved only through accurate preextraction records.

Let me note here, by way of parenthesis, a modern tendency which is making preextraction records increasingly important. We are all aware of the current theory of focal infection, which has become so widespread during the last fifteen years. Many laymen, reading articles warning them of the danger to general health which lurks in the teeth, become insistent on having the teeth roentgenographed, with the result that dentists everywhere are forced to adopt the practice of making roentgenograms. In like manner, the spread of knowledge among laymen as to the importance of preextraction records soon may compel dentists to be prepared to take these records accurately before attempting the extraction of teeth.

Several methods of taking preextraction records are in use today. Perhaps the outstanding are those methods which employ a wax mask of the face, photographic records or a profile of exact size which is cut out and fitted to the face.

Now, there are objections to all these methods. First, they require elaborate and costly equipment. Secondly, when they are used, the teeth can be positioned only by measurement and by visual comparison. In using these methods, we cannot be sure that the artificial dentures are in exactly the same cranial position as were the natural teeth. I have devised a lingual matrix which, as a result of long use, I know insures the absolute positioning of teeth as they were before extraction. Furthermore, this matrix may be used without special equipment.

Another point worth stressing is that, by using this lingual matrix, the dentist is able to position the teeth exactly whether he is practicing immediate denture technic or replacement is delayed. Uniform thinness of the palate is preserved as well as the lingual form of the teeth. The matrix assures not only comfort of the tongue but also perfect enunciation. Furthermore, the labial and buccal outlines are kept in the position where nature placed them before extraction. Thus, naturalness of expression—which, as I observed previously, is of primary importance to the patient—is preserved.

# THE PROBLEM OF THE ARTICULATOR (BALANCED OCCLUSION)*

By RUPERT E. HALL, D.D.S., Chicago, Ill.

THE primary purpose of an articulator has been to reproduce movements of the mandible for use in balancing occlusion.

Experience has taught us that, because of their intricacy, accurate reproduction of the movements of the mandible in an articulator has not been accomplished and that it is doubtful if such will ever be accomplished. The more modern idea of the function of an articulator is to have it reproduce positional relations of the mandible.

Unlike movements of the mandible, positional relations of the mandible can be accurately reproduced in an articulator.

## POSITIONAL RELATIONS OF THE MANDIBLE

The positional relations of the mandible are:

A. Centric relation: the relation of the mandible to the maxilla when the teeth are in centric occlusion (the bite) or the relation that would maintain if the teeth were present.

B. Eccentric relations:

1. Protrusive relation: the relation of the mandible to the maxilla when the teeth are in incisive occlusion or the relation that would maintain if the teeth were present.

2. Lateral relation: the relation of the mandible to the maxilla when the teeth are in lateral occlusion or the relation that would maintain if the teeth were present.

3. Intermediate relation: the relation of the mandible to the maxilla anywhere between the protrusive and a lateral relation when the teeth are in occlusion or the relation that would maintain if the teeth were present.

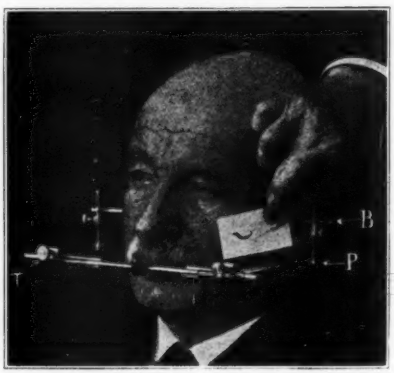



Fig. 1.—Graphic registration of slant (degree) and form of condyle path. (After Gysi, Dental Cosmos, 1910.)

## FUNCTIONAL POSITIONAL RELATIONS OF THE MANDIBLE

The functional positional relations of the mandible are:

A. Relations of occlusion: relations of the mandible within the range of occlusion of the teeth.

Range of occlusion: the distance from centric occlusion that the teeth make and

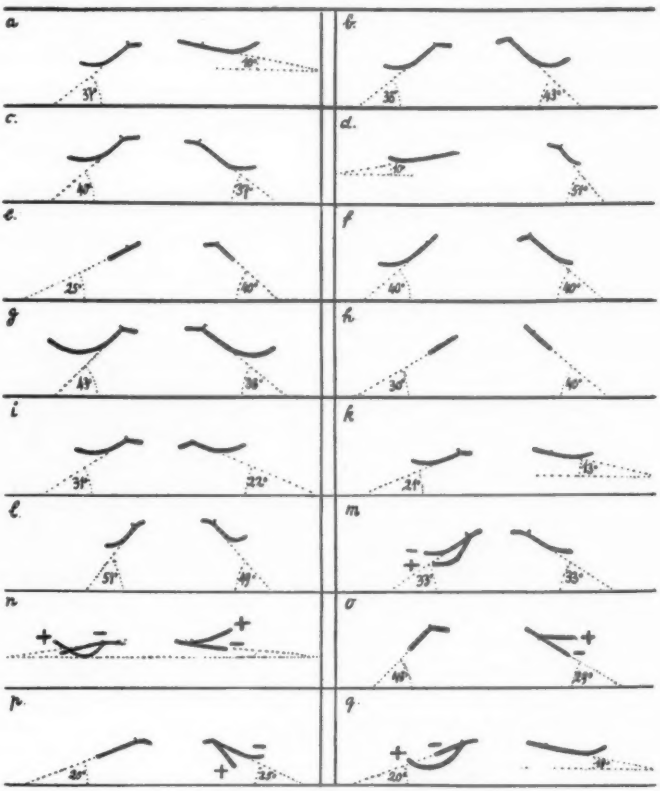
*Excerpts from a paper read before the American Academy of Restorative Dentistry, Buffalo, N. Y., Sept. 10, 1932.

maintain contact during the movement of the mandible toward and away from centric occlusion.

B. Relations of prehension and mastication: relations of the mandible beyond the range of occlusion of the teeth.

The salient point in this discussion is the importance of the relations of occlusion of the mandible to the maxilla as contrasted with the relations of prehension and mastication as they relate to occlusion of the teeth and as they concern the dentist.

Balanced occlusion: occlusion present-




(From The Dental Cosmos.)

Fig. No. 132. Typical Forward Condyle Paths.

The paths "a" to "l" inclusive show differences in form and slant of the right and left paths in the same patient.

The paths "m" to "q" show that other differences in form or slant may occur between the path of the opening movement and the path of the lateral movement of the mandible.

The path of the lateral movement alone has value in the articulation of artificial teeth.

Fig. 2.—Illustration by Gysi showing variability of slant and form of condyle path.

ing the greatest possible number of occlusal contacts in any occlusal positional relation of the mandible reciprocal with all other occlusal relations without interference during movement of the mandible (sliding of the teeth) from one relation to another relation.

The relations of prehension and mastication have no bearing on balanced occlusion as defined and are of no interest to the dentist in occluding teeth.

### MOVEMENTS OF THE MANDIBLE

The movements of the mandible are controlled by the muscles, the teeth and the condyles.

The movements of the mandible are not movements of fixed direction, but are variable. For example, the path

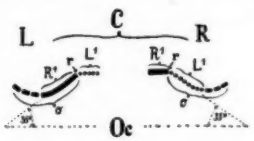



Fig. 129.

(From The Dental Cosmos.)

Analysis of right and left condyle paths as secured by the method shown in Fig. 122. C, Condyle path. L, Left. R, Right. Oc, Plane of occlusion. 35°, Angle of middle part of path to plane of occlusion. r, Resting position of condyle. R', Path of condyle in a right lateral movement. L', The same in a left lateral movement. o, Forward bite or wide opening and closing movement.

Fig. 3.—Illustration by Gysi showing analysis of condyle path tracings in which he determines degree (slant) of main part of paths to occlusal plane.

(degree and form) of the movement of the condyle varies as the distance within which the condyle moves (Figs. 1-3). This applies also to the mandible as a whole.

Note that the form of the condyle path is that of a double or reverse curve formed by the union of a convex and a concave line resembling a flattened letter S. A double (S) curve is used to denote architectural and mechanical forms and is known as an "ogee" curve (Fig. 4).

The ogee curve of the condyle path is due to the ogee curve formed by the floor of the glenoid fossa and the eminentia articularis (Figs. 5-6), which guides the movement of the condyle. The form of the condyle path is, therefore, a counterpart of the form of the glenoid fossa and the eminentia articularis (variation due to the interposed meniscus and action of the muscles considered).

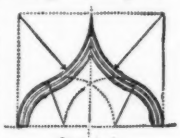
Figures 7 and 8, together with their description, are from Prothero.[1] Figure 7 demonstrates the variability of the

**ogee** (ō-jē′), *n.* [Also written *O G*, as if descriptive of the double curve (so S is used to denote another double curve, and L, T, Y, etc., are used to denote architectural or mechanical forms resembling those letters), but held by some to be a corruption of *ogive*, a pointed arch—a sense, however, totally opposed to that of *ogee*.] 1. A double or reverse curve formed by the union of a convex and a concave line.—2. In *arch.*, etc., a molding the section of which presents such a double-curved line; a cyma.

Ogee Moldings.
1. Early English period. 2. Decorated period. 3. Perpendicular period.

In medieval architecture moldings of this kind assumed characteristically different forms at different periods. *Ogee* is frequently used attributively. See cuts under *cyma* and *roof*.

3. In *artillery*, such a molding formerly used for ornament on guns, mortars, and howitzers.—**Ogee arch**, a form of arch common in late medieval architecture, with doubly curved sides, the lower part of each side being concave and the part toward the apex convex.—**Ogee roof**, a roof of which the outline is an ogee. See cut under *roof*.—**Reversed ogee**, in *arch.*, the cyma reversa molding.



Ogee Arch.

Fig. 4.—Definition and illustrations of ogee curve. (From Century Dictionary.)

condyle path, and Figure 8 demonstrates the method of adjusting the guides of the articulator to the slant (degree) of the condyle path to the occlusal plane (Figs. 1-3).

The method of registering the slant of the condyle path and adjusting the articulator guides shown in Figure 8 is that

1. Prothero, J. H.: D. Summary, 33:170 (March) 1913.

of Carl Christensen.[2] It is the original of the intra-oral method of registering positional relations of the mandible. From this method of registering the slant of the condyle path to the occlusal plane in edentulous cases, with occlusion rims, was evolved the wax checkbite used in connection with dentures and natural teeth (Figs. 17, 18 and 20), popularized by the late George S. Monson.

Figure 9 shows an ogee curve and many angles of condylar movement. Figure 10 is an illustration (my own) of the variability of the condyle path.

This demonstration shows that the path of the movement of the condyle

Fig. 5.—Dotted curves outlining ogee curve formed by floor of glenoid fossa and eminentia articularis. (By the author.)

varies between 45 and 35 degrees (a difference of 15 degrees) during the movement of the mandible from centric relation *(0)* to protrusive relation *(2)*, and that occlusion with overjet and overbite *(1)* cannot be balanced to articulator movement (Fig. 8) based upon relation *(2)*; that, in order to balance occlusion to relation *(1)* in an articulator, it is necessary to adjust the articulator guides (Fig. 8) to relation *(1)* (range of occlusion), and vice versa, if it is desired to balance occlusion to relation *(2)*, or to have the articulator condyle path guides reproduce the form of the condyle path. Attempt to adjust articulator guides to relations within the range of occlusion and to reproduce the form of the condyle path is impracticable, as we shall see as we proceed in the subject.

Other variations in the form and degree of the condyle path occur between the path of the protrusive movement and the path of the lateral movement of the mandible, as pointed out by Gysi in Figure 2 and as shown in Figures 11-12.

It is obvious that a different slant and form of condyle path is produced when the condyle moves obliquely over the eminentia articularis (ogee curve) from that resulting when it moves more nearly squarely over the eminence, and that a path different from either of these paths is produced when the condyle on the working side moves outwardly in the glenoid fossa. Such movements compare with those of a person ascending a mountain and walking around a mountain. When walking up a mountain in a straight line from its base to its summit, one pursues a different path from that followed in walking diagonally up and around it, and still another path when walking around the base of the mountain.

The foregoing disclosures show that occlusal positional relations and movements of the mandible cannot be determined without teeth present to direct its movements and relations. The variations in the form and arrangement of the teeth (cusp depth, overjet, overbite and curve of Spee) and in the movements of the mandible (as demonstrated) are largely coincidental, either determining, in part, the other, and either being, in a large measure, equal to the other. Because of esthetics, ridge relation, etc., etc., the form and arrangement of the teeth take

2. Christensen, Carl: A Rational Articulator, Ash's Quarterly Circular, 1901; Problem of the Bite, D. Cosmos, 47:1184 (Oct.) 1905.

precedence over the movements and relations of the mandible.

Occlusion, it is seen, is balanced in ratio to the fidelity with which the occlusal movements and relations of the mandible are observed and utilized in its construction. The customary registration of the mandibular relations beyond the range of the occlusion of the teeth (movements of prehension and mastication) is thus shown to be delusive and wrong.

Only those movements and relations of the mandible within the range of the occlusion of the teeth are of interest and value to us in occluding and balancing teeth. Through their use only can we truly effect balance.

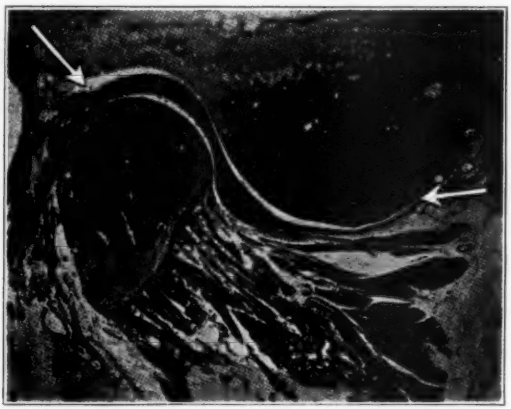


Fig. 6.—Section of adult temporomandibular articulation showing ogee curve (arrows). (After Prentis.)

### REGISTERING OCCLUSAL POSITIONAL RELATIONS OF THE MANDIBLE

Nature presents two forms of occlusion, namely, cusp tooth occlusion and cuspless tooth occlusion, the former at the beginning of life; the latter, because of wear of the teeth, in old age.

The replacement or restoration of teeth is done both with cusp teeth and with cuspless teeth, through either necessity or choice.

Cusp teeth demand that the mandible open in order that the occlusion may function; whereas, with cuspless teeth, the occlusion functions without the opening of the mandible.

Movements of the mandible embodying the opening movement are entirely different from those not embodying the opening movement. Those movements embodying the opening movement are three-dimensional (opening, lateral and backward [arcuate] movement), and those not embodying the opening movement are two-dimensional (lateral and forward [gothic arch] movement).

Cusp tooth occlusion is a three-dimensional occlusion; whereas, cuspless tooth occlusion is a two-dimensional occlusion.

In order to construct (balance) occlusion in an articulator, it is necessary to register, and to have the articulator record and reproduce, mandibular relations that harmonize with the form of teeth (occlusion) that we employ. For cuspless tooth, two-dimensional occlusion, we require registrations of two-dimensional occlusal relations of the mandible;

and for cusp tooth, three-dimensional occlusion, we require registrations of three-dimensional occlusal relations of the mandible.

Registering occlusal relations of the mandible will not be shown or discussed at this time beyond the point necessary to demonstrate the relations of occlusion of the mandible, this being a subject requiring special and lengthy consideration. It is the aim of this discussion to deal more particularly with reproducing occlusal relations of the mandible in the articulator.

Because of its simplicity and popularity, wax checkbites (Figs. 17, 18 and 20) for registering occlusal relations of the

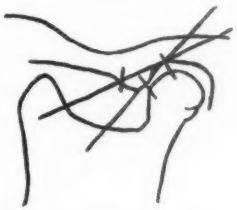


**Fig. 7.—Two possible condyle registrations in same individual. The less inclined and longer one is produced by an excessive protrusion, and consequently is incorrect. The steeper path, representing more nearly the limit of travel of the condyle head in normal masticatory effort, is obtained by having the patient protrude the mandible about 5 mm. in taking the protrusive bite. (Diagram and description from Prothero.)**

mandible will be used in the demonstrations to follow.

For convenience and economy, we require an articulator that will record and reproduce either two or three dimensional occlusal relations of the mandible. Such an articulator will now be discussed.

A simplified, more accurate and more practical method of reproducing occlusal relations of the mandible, either two or three dimensional relations, for studying and balancing occlusion, is provided for in a plane-line articulator to which is added a record cup (Fig. 13). By the aid of the record cup, the plane-line articulator is made 100 per cent adaptable.

The name that has been chosen for this articulator is "universal articulator."

## REPRODUCING OCCLUSAL RELATIONS OF THE MANDIBLE

Casts of natural teeth with cusps will be used to demonstrate occlusal relations of the mandible and the adaptable feature of the universal articulator, it being understood that the demonstration is applicable either to cusp or cuspless teeth and also to edentulous cases, using either cusp or cuspless teeth.

The first step in the use of the universal articulator as an adaptable instrument is to mount the upper cast.

Locating the casts in the articulator preparatory to mounting the upper cast is accomplished by supporting the lower cast with three pieces of modeling clay placed in the bottom of the record cup, one in the front and one at either side at the rear (Fig. 14). The lower cast should be positioned in the center of the cup and lack about three-eighths inch of touching the bottom of it so that it can be moved forward, sidewise and downward without coming it contact with the cup when moved to eccentric positions.

With the casts so positioned, and supported with the modeling clay, the upper arm of the articulator is adjusted to a convenient height with the guide pin, which is set to any one of the heavy line graduations (Figs. 13 and 14*A*). The upper cast is next luted (plastered) to the upper arm (cast plate).

To record checkbite registrations of occlusal relations of the mandible, both centric and eccentric relations, in the universal articulator, the base of the lower cast is tapered (Fig. 15) so that it will draw from, and make interchangeable, the plaster records *C, RL, P* and *LL* (Figs. 15, 17, 18 and 20).

Three cone-shaped pieces of modeling clay are placed in the bottom of the record cup as in mounting the upper case. These act as a support for the lower cast when brought in contact with them on closure of the articulator (Fig. 16) and form push-out holes through which the cast can be removed from the plaster record.

With the upper cast mounted as described, and the lower cast wet and the base of it soaped so as to prevent the plaster sticking, the record cup is filled with plaster and the lower cast carried to the mandible are reproduced merely by changing from one plaster record to another.

Occlusion in any of its forms—natural or artificial, either two or three-dimensional—can be studied, modified or constructed (balanced) according to plaster records so made with the assurance that they are as faithful a reproduction of the positional relations of the mandible as are the checkbites from which they are made.

A plaster record made in the manner described has incorporated in it all of the

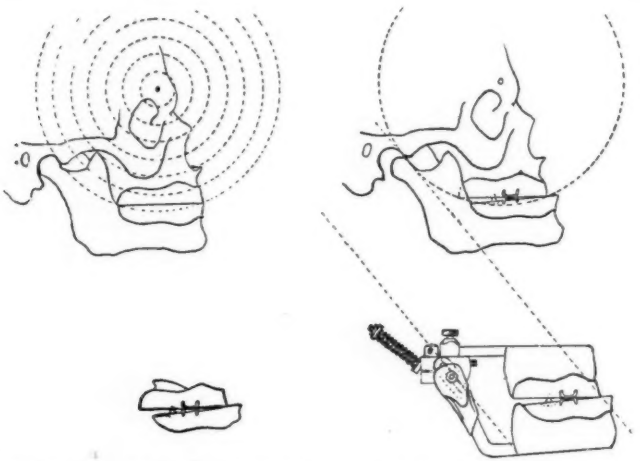


Fig. 8.—Relationship of baseplates in their normal and protruded positions, removal of baseplates from mouth and their return to models. The parallel relation between the condyle path in the upper right figure and the condyle slots of the frame are to be noted. (Diagram and description from Prothero.)

place in the cup, a plaster record of an occlusal relation of the mandible resulting according to the checkbite used (Figs. 16 and 17), and so on, until the four positional relations (centric, right and left lateral and protrusive) are recorded, one plaster record (four in all) for each positional relation (Fig. 18).

The plaster records furnish the means by which the various occlusal relations of individuality of the movement of the mandible of the subject for whom it is made, i.e., any positional relation the mandible may assume as the result of movement.

Figure 19 shows a plaster record of a lateral relation of the mandible depicting the various movements of the mandible that it records.

Whether or not the mandible moves

about a central axis (arcuate movement), about a right or left axis (gothic arch movement), about a central point (spherical movement) or shifts laterally (Bennett movement) or the condyle path is 10 degrees or 40 degrees, the plaster record reproduces the condition precisely as nature has it. It is not speculative and it makes no compromise.

Articulator movement, in the sense of accurately imitating mandibular movement, is, as has been stated, impossible of accomplishment, at least it has not been accomplished up to the present time. This forces us to go directly to the mouth, if movements of the mandible are to play any rôle in balancing occlusion. Having the patient chew carborundum is the only way occlusion can be accurately ground-in to the movements of the mandible, if so fine a result is desirable.

The magnitude of a lateral movement of the mandible held within the range of the occlusion of the teeth, viewed from the standpoint of measurement (distance to, or away from, centric relation), is so slight as to be practically immeasurable in the region of the condyles. Tests have shown this movement to be not greater than one-sixteenth inch at the incisor point in the average case. Accurate reproduction of so slight a mandibular movement or relation in a mechanically adjustable articulator is impossible because the magnitude of the movement is not sufficient to direct adjustment of the articulator guides. Hence, the time old practice of registering excessive mandibular relations. Mechanically adjustable articulators require such; for only with registrations so made can adjustment of their guides be indicated. (This applies to the three-dimensional [tripod] style of articulator construction [my invention] the same as to any other form of mechanically adjustable articulator. Reversing the order of its guides [mounting the casts backwards] does not overcome the difficulty.)

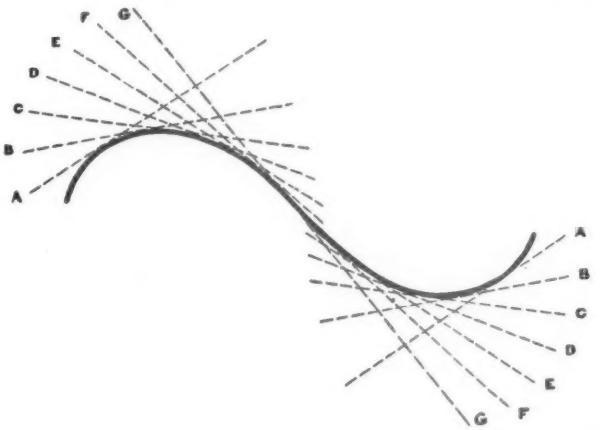



Fig. 9.—Ogee curve and many angles of condylar movement. (Illustration from Bunce-Kanouse: "Full Denture Technic.")

It has been the practice in the past to register excessive mandibular relations

(relations of prehension and mastication), adjust articulators to them and then use only movements in the articulator within the range of occlusion of the teeth, assuming them to be movements of occlusion and the occlusion constructed according to them to be balanced. It is shown that occlusion so constructed is not balanced. The apparent balance of dentures in the mouth cannot discount the fact that the occlusion is not balanced, because the resiliency of the supporting tissues and tipping of the dentures permits the dentures to take such positions as may be required to effect balance on the surface and, in consequence, deceive us in our interpretation, as is definitely and undeniably shown to be the case.

Does it not seem that the answer as to whether occlusion of the teeth is balanced lies in the understanding and execution of the fundamentals that make balance possible rather than in a superficial examination of a set of mobile dentures in the mouth?

The answer to the question, in the light of our present knowledge, is in the affirmative.

For the reason that the movement of the mandible varies within the distance the mandible moves, as well as according to the direction it moves (protrusive, right and left lateral movement), and the form and arrangement of the teeth determines the range of occlusion, it is necessary to have, or to create, occluded teeth, in order to know where to position the mandible when taking checkbites so that the positions used will be those assumed by the teeth. It is only with checkbites so taken that we can hope to balance occlusion accurately to the patient's individual occlusal relations in an articulator.

Registration of the lateral relations should be of positions not quite to and never beyond the distance that brings the buccal surfaces of the posterior teeth flush with one another on the working side. A lateral movement of the mandible so limited measures from one-sixteenth to

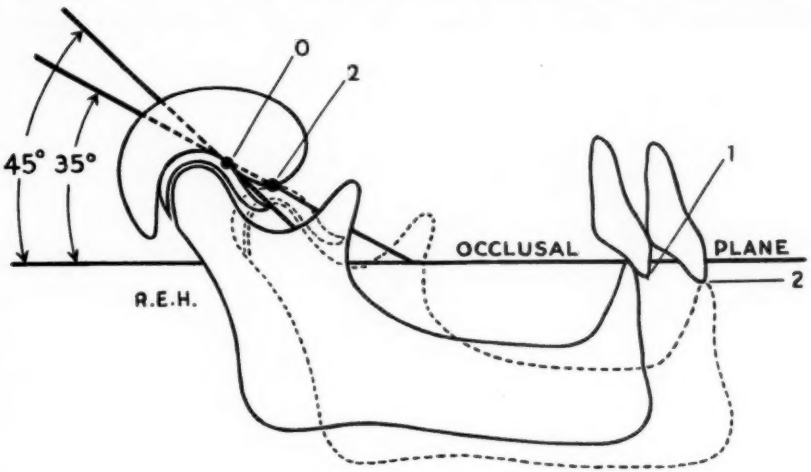



Fig. 10.—Movement (path) of condyle, which varies as distance within which condyle moves. (By the author.)

three-thirty-seconds inch at the incisor point. Registration of the protrusive relation should be of the position the mandible assumes when the anterior teeth are flush with one another. This distance varies greatly. (Fig. 10, *1-2.*)

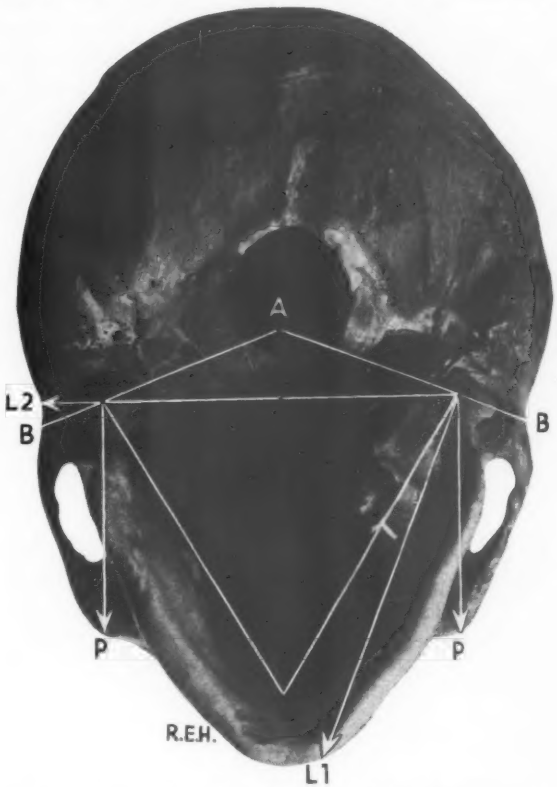



Fig. 11.—Lines *(BAB)* showing acute angle that glenoid fossae, eminentia articularis and condyle heads bear to the median plane. During protrusive movement of the mandible, the condyles move forward obliquely over the eminentia articularis *(PP)*. During a lateral movement of the mandible, the condyle on the balancing side moves forward and inward more nearly squarely over the eminentia articularis *(L1)* and the condyle on the working side outward *(L2)*. (The inward movement of the balancing condyle *(L1)* and the outward movement of the working condyle *(L2)* is the Balkwill-Bennett movement [Fig. 12].) (By the author.)

MOUNTING CASTS OF EDENTULOUS CASES

As has already been stated, casts of cases without teeth are mounted in the universal articulator in the same manner as shown for mounting casts of natural teeth (Fig. 20).

If it is desired first to use the articulator as a plane-line and later as an adaptable articulator, we should proceed as follows:

In place of mounting the lower cast

in the record cup, by pouring plaster around it, forming a centric plaster record as shown in Figure 16, remove the record cup after mounting the upper cast and attach the lower cast to the lower arm (cast plate) (Fig. 21). This procedure positions the casts in the articulator so that the record cup may be used later on, the casts having been correctly positioned in anticipation of its use.

SETTING UP (BALANCING) THE TEETH

In anticipation of "grinding in" the occlusion of the teeth in the articulator, it is desirable to open the bite of the articulator two points on the guide pin (light line graduations, Fig. 14) before proceeding with the arranging of the teeth, so that in grinding in the occlusion, the bite will be closed to its original position, the occlusion being ground to the bite rather than away from it. This prevents shortening the bite and throwing off the relation of the casts, one to the other, owing to the articulator's closing differently from the mandible. (If the teeth are to be ground-in in the mouth, the same provision should be made to prevent shortening the bite from the standpoint of esthetics and anatomy.)

When the bite is not changed in the articulator, exact location of the opening axis of the mandible in the articulator is of no importance. This dispenses with the facebow in this connection and it is for this reason that the facebow is not so shown nor mentioned as a part of the technic in the use of the universal articulator.

If it is necessary to open or close the bite, secure a new bite from the patient, detach the upper cast and remount it according to the new bite. This procedure is desirable with the use of any articulator, whether the facebow is used or not; for no articulator can be depended on to open or close exactly as the mandible itself opens and closes.

It is permissible, and expedient, to change the bite in the articulator tentatively as an aid in determining the exact opened or closed relation (bite) that is required when changing the bite; following which the upper cast is remounted in the articulator according to the new bite and the teeth arranged (the arrangement corrected, where indicated) accordingly.

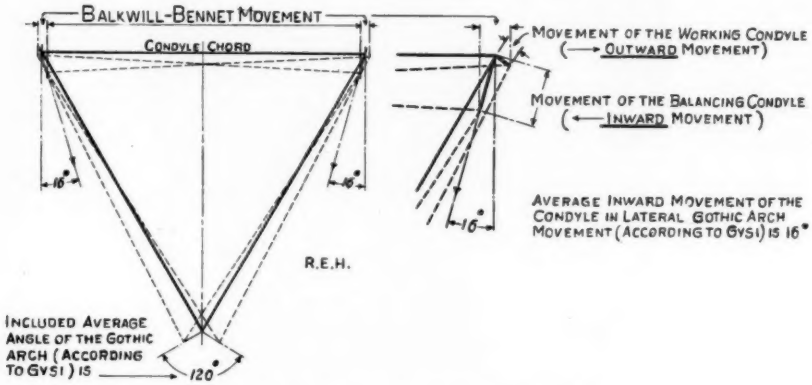

BALKWILL-BENNET MOVEMENT
CONDYLE CHORD
16°
16°
R.E.H.
INCLUDED AVERAGE ANGLE OF THE GOTHIC ARCH (ACCORDING TO GYSI) IS
120°
MOVEMENT OF THE WORKING CONDYLE (→ OUTWARD MOVEMENT)
MOVEMENT OF THE BALANCING CONDYLE (← INWARD MOVEMENT)
16°
AVERAGE INWARD MOVEMENT OF THE CONDYLE IN LATERAL GOTHIC ARCH MOVEMENT (ACCORDING TO GYSI) IS 16°

Fig. 12.—Balkwill-Bennett movement of mandible. (By the author.)

The teeth arranged in centric relation, we are now ready to secure checkbites changing the arrangement of the teeth as required to effect balance.

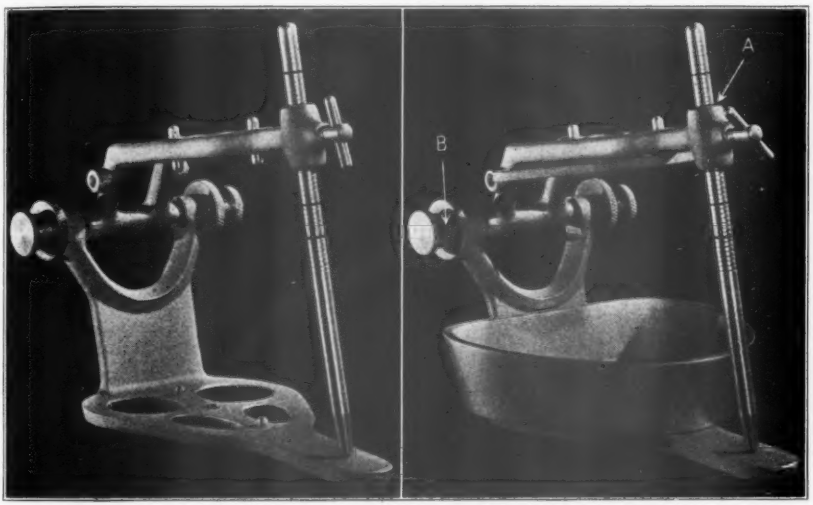



Fig. 13.—Plane-line articulator to which is added a record cup, designated "universal articulator."

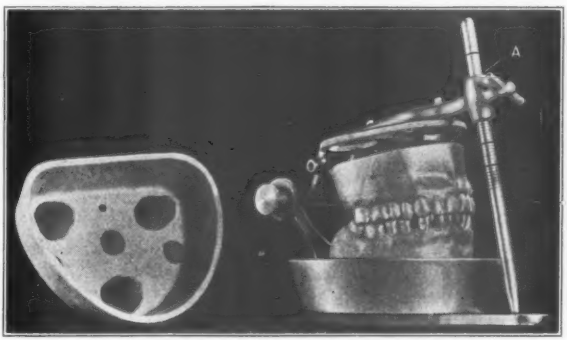



Fig. 14.—Positioning casts in universal articulator preparatory to mounting upper cast.

of the eccentric occlusal relations of the mandible as guided by the arrangement of the teeth (using whatever method is most acceptable to us), make plaster articulator records therefrom and balance the occlusion according to them,

## "GRINDING IN" THE OCCLUSION IN THE UNIVERSAL ARTICULATOR

The occlusion may be spot ground with the aid of carbon paper and a stone in the handpiece, the articulator being

used to relate the teeth in the various positional relations according to the plaster records; or the articulator may be converted into a grinding machine.

### CONVERTING THE UNIVERSAL ARTICULATOR INTO A GRINDING MACHINE

In order to make the universal articulator movable, so that grinding in the occlusion in the various positional relations according to the plaster records may be effected with motion, a double thickness of rubber dam is interposed between the bearing points of the screws forming the hinge joint (Fig. 22).

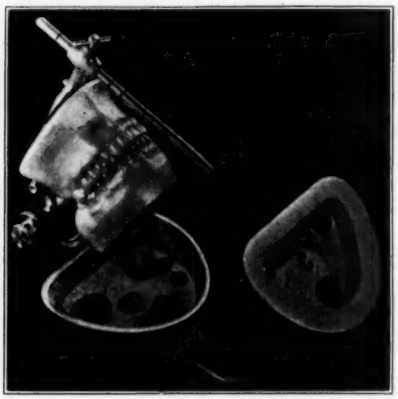


Fig. 15.—Upper cast mounted in universal articulator preparatory to pouring a plaster record of centric relation of mandible.

A vertical mark is made on the top half of the face of the screw heads with a lead pencil (Fig. 23), which is used as a guide to effect equal adjustment (withdrawal) of the screws in determining the desired tension on the interposed rubber. Adjusting the screws to within about one-quarter turn of their set up positions (Fig. 22) effects about the proper tension on the rubber.

Carborundum is now applied to the teeth, and motion of the upper arm of the articulator effects a grinding in of the occlusion according to the plaster records of the positional relations of the mandible. The occlusion is ground in first to protrusive relation, then to centric relation and lastly to right and left lateral relations.

The universal articulator is a departure in principle from the usual articulator in that the lower cast is changed in relation to the upper by moving the cast itself and not the articulator, the articulator remaining fixed (static) and serving only as a means by which to establish and maintain static relations of the casts to one another according to the plaster records.

Grinding in the occlusion to lateral relations according to plaster records made from lateral checkbites limited to the occlusal relations of the mandible, because of their close proximity to centric relation, produces continuous occlusion from a lateral relation to centric relation, and vice versa. This dispenses with the need for lateral movement in the articulator other than that permitted by the rubber interposed in the hinge joint.

Grinding in the occlusion between protrusive and centric relations may be done with a checkbite and plaster record of an intermediate relation or done directly in the mouth.

Cuspless tooth (two-dimensional) occlusion (Fig. 21) may be constructed and ground in according to plaster records of the various two-dimensional occlusal relations of the mandible or, because of its simplicity and the greater ease with which two-dimensional occlusion is constructed, as compared with cusp tooth three-dimension occlusion, the teeth may be arranged arbitrarily according to a template or one's experience and judgment, using the universal articulator as a plane-line articulator (Fig. 21) and grinding in (balancing) the occlusion directly in the mouth. I use the latter

method almost entirely because I find it satisfactory as well as easier and quicker.

THE UNIVERSAL ARTICULATOR A GENERAL USE ARTICULATOR

Figure 13 shows the universal articulator without the record cup, making of it a plane-line articulator.

Figure 24 shows the universal articulator with the upper arm inverted, reducing the space between the arms. This saves material.

THE UNIVERSAL ARTICULATOR A DUPLICATING, REBUILDING AND REBASING INSTRUMENT

Figure 24 shows the universal articulator adapted to duplicating, rebasing and rebuilding dentures. By the releasing of the two set screws forming the hinge joint, the teeth can be lifted from the plaster bite (matrix). This feature of the universal articulator is a most valuable and timely contribution to articulator construction. It fulfils a re-

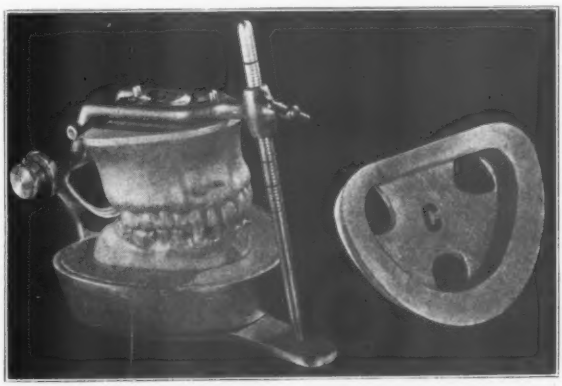



Fig. 16.—Plaster record of centric relation of mandible completed.

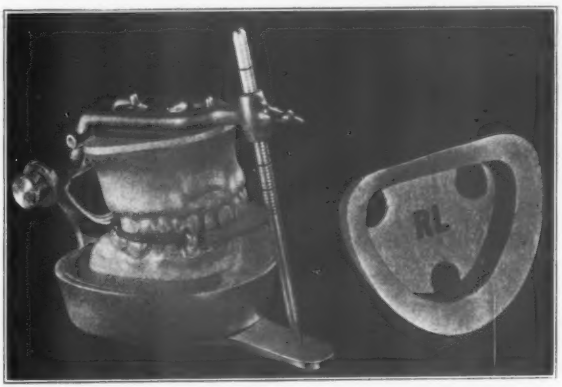



Fig. 17.—Plaster record of right lateral occlusal relation of mandible according to right lateral wax checkbite.

quirement long recognized in a simple and practical manner.

The cast plates, record cup and graduated bitepin permit preservation of every record (plane-line or adaptable) so that they may be filed for future use.

The universal articulator presents no complications, whether used as an adaptable articulator, as a plane-line articulator or as a duplicating, rebuilding and rebasing instrument.

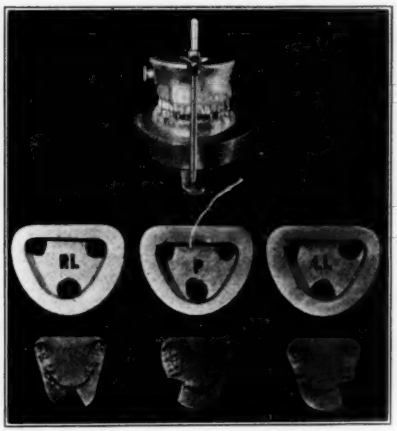



Fig. 18.—Plaster records of centric, right and left lateral and protrusive relations of mandible (natural teeth) according to centric occlusion of teeth and right and left lateral and protrusive wax checkbites.

## SUMMARY

1. Nature presents two forms of occlusion; namely, cusp tooth and cuspless tooth.

2. The replacement or restoration of teeth is done both with cusp teeth and with cuspless teeth.

3. Cusp tooth occlusion is a three-dimensional occlusion; cuspless tooth occlusion is a two-dimensional occlusion.

4. In order to balance occlusion in an articulator, it is necessary to register, and to have the articulator record and reproduce, mandibular relations that harmonize with the form of teeth employed.

5. For cuspless teeth (two-dimensional occlusion), we require registrations of two-dimensional occlusal relations of the mandible; for cusp teeth (three-dimensional occlusion), registrations of three-dimensional occlusal relations of the mandible.

Cusp tooth three-dimensional occlusion cannot be balanced in an articulator reproducing two-dimensional gothic arch movement and cuspless tooth two-dimensional occlusion cannot be balanced in an articulator reproducing three-dimensional

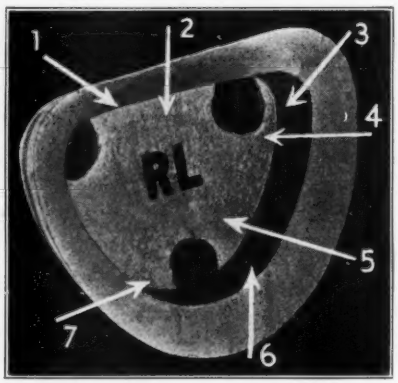



Fig. 19.—Plaster record of a lateral relation of mandible depicting various movements of mandible that it records: (1) downward movement of balancing condyle; (2) inward movement of balancing condyle (Balkwill-Bennett movement); (3) outward movement of working condyle (Balkwill-Bennett movement), forward, backward and up and down movement of working condyle; (4) opening movement, if record of three-dimensional movement; (5) arcuate movement (movement about central axis) if record of three-dimensional movement; (6) gothic arch movement (movement about right and left axis) if record of two-dimensional movement (right axis in this case); (7) spherical movement, if movement of mandible is spherical, etc.

arcuate movement. (In spite of its inconsistency, attempt to so balance the former is common practice.)

6. The movements of the mandible vary within the distance the mandible moves, also according to the direction it moves. Therefore, the condyle paths are different for each eccentric movement and positional relation of the mandible (right and left lateral and protrusive) and for each form of occlusion.

7. Movements and relations of occlusion (movements and relations of the mandible within the range of occlusion of the teeth) are different movements and relations from those beyond the range of occlusion of the teeth.

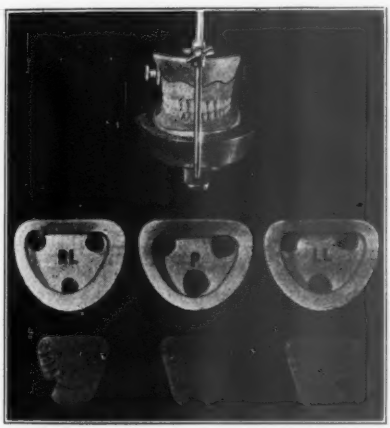


Fig. 20.—Plaster records of centric, right and left lateral and protrusive relations of mandible (artificial teeth) according to centric relation and right and left lateral and protrusive wax checkbites.

8. Movements of prehension and mastication (movements and relations of the mandible beyond the range of occlusion of the teeth) have no bearing on occlusion and are of no interest to the dentist in constructing and "grinding in" occlusion. (Registration and reproduction of these movements and relations is delusive and wrong.)

9. Owing to the fact that the movements of the mandible vary coincidentally with movement of the mandible, occlusion can be balanced in articulators adjusted to checkbites of movements and relations held within the range of occlusion of the teeth only. Therefore, only movements and relations of the mandible within the range of occlusion of the teeth are of interest to the dentist in occluding teeth.

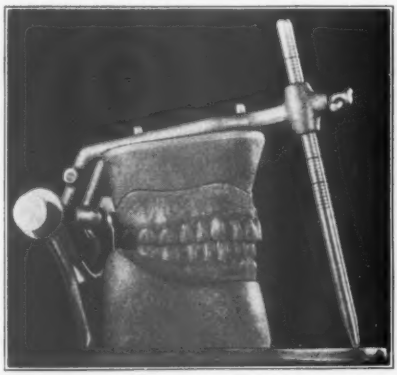


Fig. 21.—Cuspless tooth two-dimensional occlusion arranged in a plane-line articulator.

10. In order to limit movements and relations of the mandible to the range of occlusion of the teeth, it is necessary to have or create teeth (because of the difference between two and three dimensional occlusion and the varying arrangement of the teeth) in order to know where to position the mandible in taking checkbites. (This is a reversal of the order as now practiced.)

11. Articulators cannot accurately reproduce individual movements of the mandible because the movements of the mandible are too intricate and variable to permit of accurate mechanical reproduction of them. Therefore, in order to

balance occlusion to the movements of the mandible, it is necessary to have the patient chew carborundum, if so fine a result is desirable.

12. Mechanically adjustable articulators cannot accurately reproduce individual occlusal positional relations of the mandible because the magnitude of the movements of occlusion are too minute to direct adjustment of the articulator guides.

13. Individual positional relations of the mandible can be accurately reproduced in an articulator with plaster records.

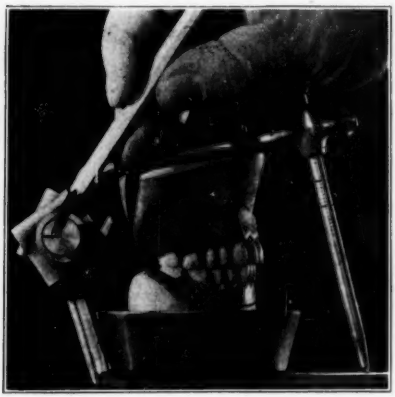


Fig. 22.—Double layer of rubber dam interposed between screw centers of hinge joint of articulator to permit motion of upper arm of the articulator for grinding-in occlusion. The set screw with cross-drilled hole (hole to enable setting the screw up tight) is always securely set up all the way except in using the rubber dam. All adjustments of the set screws except those made in connection with the use of the rubber dam are made with the other (plane) set screw.

14. Because of the minuteness of the magnitude of the eccentric occlusal movements and relations of the mandible, movement in the articulator is dispensed with, these relations being so close to centric relation as to make movement in the articulator unnecessary.

15. Cuspless tooth two-dimensional occlusion is less complicated than cusp tooth three-dimensional occlusion and is readily and easily arranged in a plane-line articulator and balanced in the mouth, both to the occlusal relations and to the movements of the mandible.

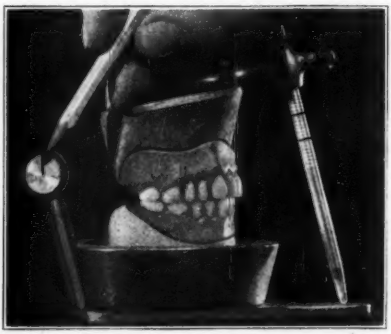


Fig. 23.—Making a vertical pencil mark on top half of face of set screw heads (both screws), using any thing square, such as a visiting card, as a guide.

Fig. 24.—Upper arm of universal articulator inverted; plaster matrix used to rebase, rebuild and duplicate dentures.

# EVALUATION OF THE THEORY OF FOCAL INFECTION*

By EDWARD H. HATTON, B.L., M.D., Chicago, Ill.

## PRESENT INTEREST IN FOCAL INFECTION

IN the Dental Exhibit at the Century of Progress, there is shown a reproduction of baked tablets and a translation of the inscription on them, a report of the royal physician to a great monarch, informing him that he must have his teeth extracted in order to be cured of his disease; carrying the concept of focal infection back to antiquity. Holman cites Hippocrates as describing two cases of the eradication of rheumatism by elimination of mouth infection. Much more recently, the same notion has been found in the papers of John Abernethy (1809), Benjamin Rush (1818), Trousseau (1865) and many others.

The high tide in the evolution of this theory has been reached only in our generation, especially as far as the teeth are concerned, because of the simultaneous development of newer methods of diagnosis and concurrent changes in medical practice and investigation. Medical thought and medical practice have been greatly changed as a result of the practical conquest of many of the acute contagious and infectious diseases. With the elimination of these diseases as unknowns in the practice of medicine, interest and activity have been diverted toward the explanation and control of chronic disease, which may also be concerned with the infectious process, because of the great promise this idea offers in control and treatment. Technical and scientific dentistry has made progress in our day, which has produced conditions which tend, on the one hand, to increase certain types of mouth infection and, on the other, by its interest in research and the etiology of disease, to focus its attention on any theory that offers promise of establishing itself as an effective health promoting agency. Lastly, the introduction of the roentgen rays into dental diagnosis has had an incalculable effect in promoting attention to the dental phase of focal infection.

It has been stated that focal infection is merely a passing fad, already on the wane and to be classed eventually with other practices that were universal in their application at one time or another, such as the vogue for bleeding in Washington's day. As the focal infection concept in its modern form is approximately 20 years of age, it has seemed worth while in this connection to appraise activity in this field in the years 1922 and 1932; that is, approximately ten and twenty years, respectively, after its introduction. To do this, the articles listed in the Cumulative Medical Index under the general heads of focal infection and tooth infection have been listed and analyzed in Tables 1 and 2.

From the tabulation, all articles listed in dental journals have been excluded, and one may therefore conclude that the medical interest in this subject, at the present time, is not on the wane and that

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this conclusion is particularly true of the interest, as depicted in this way, in the tooth phase of focal infection. On the whole, it will be seen that, whereas the actual gain of interest is about 42 per cent, this gain has been brought about by the increase of articles published in the various languages other than English. The number of articles published in state medical journals has fallen off and the number published in those journals enjoying a wider circulation and, presumably, better editorial selection, has increased.

TABLE 1.—LITERATURE ON FOCAL INFECTION (1922)

| | |
|---|---|
| **Articles on Focal Infection** | |
| In journals of state societies | 23 |
| In other journals in English except special subjects | 6 |
| In journals of the specialities in English | 4 |
| In German journals | 0 |
| In other foreign journals | 3 |
| Total | 36 |
| **Articles on Infected Teeth as Primary Foci** | |
| In journals of state societies | 8 |
| In other journals in English except special subjects | 10 |
| In journals of the specialities in English | 5 |
| In German journals | 2 |
| In other foreign journals | 3 |
| Total | 28 |
| Total for both groups | 64 |

In the last decade, two attempts have been made to evaluate the theory of focal infection. Holman, in his introductory sentence, says: "Focal infection has changed, with increased evidence, from theory to a principle of medicine." (1927.) In this article he discusses a number of the diseases which may be considered to be caused in this way and the commoner locations of the primary foci. As the subjects of iritis and rheumatism in this connection are to be discussed later, the first thought in the previous sentence will not be discussed now. As to the commoner location of the primary foci, Holman subscribes to the generally extant opinion that it is the tonsils and teeth that are most often concerned.

A considerable portion of his review has to do with the matter of elective localization. He concludes:

> The specificity of the bacteria involved has not been proved, and the evidence favoring the theory of elective localization is so often open to misinterpretation and so limited in its application that it cannot be considered as any help in the solution of the problem. A certain general bacterial adaptation to environment is accepted by everyone, but the factors on the side of the host are more variable and far more important. This has been demonstrated very well in tuberculosis, and, from what is known of the types of infection that have been discussed in this review, this way of approach seems most hopeful.

TABLE 2.—LITERATURE ON FOCAL INFECTION (1932)

| | |
|---|---|
| **Articles on Focal Infection** | |
| In journals of state societies | 10 |
| In other journals in English except special subjects | 15 |
| In journals of the special subjects in English | 5 |
| In German journals | 7 |
| In other foreign journals | 16 |
| Total | 45 |
| **Articles on Infected Teeth as Primary Foci** | |
| In journals of state societies | 14 |
| In other journals in English except special subjects | 10 |
| In journals of the specialities in English | 2 |
| In German journals | 4 |
| In other foreign journals | 16 |
| Total | 46 |
| Total for both groups | 91 |

As aids in the location and diagnosis of the primary focus, Holman rejects not only the methods based on elective localization and the information derived from the inoculation of animals, but also the pathogen-selective method of Solis-Cohen

and the more complicated methods of agglutination and complement deviation.

As the subject of elective localization will not be referred to again, it seems desirable to suggest the possibility that the facts on which the theory of elective localization is based are quite capable of being interpreted in an entirely different fashion; namely, on the postulate that the organism acquires a specific affinity in what is considered to be the secondary lesion, that is, the joints or the eye, and that the specific properties of the organisms isolated from tonsils or teeth are such as they are because they have been carried from the eyes or joints to the tonsils or teeth, and not vice versa.

Irons suggests this possibility in his statement: "Occasionally the lesions that developed about the roots of pulpless teeth were truly metastatic as were those of iritis or arthritis." Lourie expresses himself more forcefully on this subject as follows:

> The theory of elective affinity, as it stands, does not solve the problem of focal infection and can hardly be of help in the treatment for ocular diseases. . . . Perhaps the ocular disease produces some changes in the fluids of the whole body which cause the streptococcus or other micro-organisms to acquire elective affinity for the eye. This assumption may explain the results of inoculation of rabbits with the streptococcus from a human being with a diseased eye regardless of whether the streptococcus has lodged in the tonsils, teeth, cervix or elsewhere.

The second evaluating monograph on the subject is that issued under the auspices of the Joseph Purcell Foundation. As this is largely bibliographic and not highly critical, it may be passed over with the comment that, as far as opinions are expressed, they are not essentially different from those of Holman, except that they are probably somewhat more favorable to the acceptance of the theory.

It may be conceded, therefore, that Holman's contention is acceptable and that focal infection, as far as the present generation of physicians and dentists is concerned, is not a theory, but a working principle, and that interest in its application and study is still at a high level without any noteworthy evidences of decline.

### FOCAL INFECTION FACTOR IN THE ETIOLOGY OF IRITIS AND RHEUMATISM

The diseases iritis and rheumatism have been selected as a basis of investigating the question as to whether clinicians and research workers are manifesting an inclination to decrease acceptance of the focal infection factor in the etiology of chronic diseases.

The successive papers of Irons and Brown and their co-workers have played no small part in calling attention to the relationship of focal infection to iritis. The force of their argument has been enhanced by the fact that many of the cases treated by the removal of the suspected foci of chronic infection have not recurred over a number of years. De Schweinitz states that chronic infection of the tonsils, teeth, sinuses, posterior urethra, seminal vesicles and pelvic organs, in the order listed, are of significance in the etiology of iritis. Veasey concludes that infected tonsils are the most important factor, while Greenwood favors oral sepsis.

Gifford, in 1931, reviewed the literature on this subject and tabulated both his own cases and those of a number of other authors. These figures are presented in Table 3. Combining these data for 1,234 cases, syphilis and tuberculosis account for 37 per cent of the cases, some single chronic infection for 40.3 per cent and an unknown or mixed etiology for the remainder, 17.6 per cent.

The percentage for tuberculosis is higher in the last column (all authors) than in the first column (Irons and Brown). Also, the estimate for teeth and

tonsils is much smaller in the last column (all authors). The original figure of 4.0 per cent for the etiology of tuberculosis in the Irons and Brown original tabulation is striking not only because of this, but also in the light of a recent paper by Irons in which he states: "In a small series of carefully studied cases there is an increasing incidence of evidence of tuberculosis and of probable tuberculous etiology in passing from acute to recurrent, to chronic iritis." There seems to be a disposition at the present time with reference to both iritis and arthritis to consider that metastatic bacterial infection in the focal sense plays a part in the initiation of the secondary lesion or lesions by sensitizing the tissues to bacterial or other toxins. In iritis, this disposition manifests itself by distinguishing rather sharply between acute, recurrent and chronic iritis, as to both pathology and etiology. Irons seems to imply that focal infection may be of more significance in the acute forms. It is fair to state that European authors are still prone to ascribe a much greater value to the relationship of tuberculosis and syphilis to iritis than to chronic infection, and that the latest paper by Irons is generally more in harmony with this notion.

These figures are offered in confirmation of the opinion already advanced that the principle of focal infection is still in good standing in the etiology of such diseases as iritis, with the reservation that present opinion tends to a much more conservative evaluation of the focal infection factor.

As to rheumatism and arthritis, the situation is less clear. Jordan says in his review, "The Microbic Etiology of Rheumatic Fever and Arthritis":

> There seems to be little doubt that rheumatic fever and some forms of arthritis are usually due to infections with micro-organisms. That many different organisms can cause joint disorders in animals and in man seems also beyond the possibility of doubt. More than that has not been absolutely established. . . . Streptococci have also been obtained from dental abscesses or pulpless teeth with arthritis. The work of Rosenow and Ashby, Rosenow, Price, Willcox, Franke, Hurst, Haden, Watson-Williams, Davis, Meisser and Brock and many others has done much to establish the facts of dental focal infection. Unfortunately, the same lack of uniformity in the type of streptococci isolated has provoked a sense of confusion and futility difficult to surmount. Nevertheless, streptococci have been found, often in pure culture, in dental foci; removal of these foci has resulted in clinical cure so often that indirect evidence of their causative connection in some instances seems convincing. The hypothesis of "elective localization" advanced by Rosenow has perhaps received its greatest support in the study of dental streptococci. Altogether such a mass of evidence has been collected on this subject both pro and con, many having failed to substantiate these results of elective localization, that the only possible position is to suspend judgement.

TABLE 3.—ETIOLOGY OF IRITIS

| | Irons and Brown 200 Cases Per Cent | Gifford 118 Cases Per Cent | All Authors 1,234 Cases Per Cent |
|---|---|---|---|
| Syphilis | 19.0 | 16.95 | 19.8 |
| Tuberculosis | 4.0 | 8.5 | 17.2 |
| Tonsils | 26.5 | 22.0 | 9.3 |
| Teeth | 13.5 | 12.7 | 11.1 |
| Sinuses | 2.0 | 6.8 | 2.3 |
| Other chronic infections | ... | ... | 17.6 |
| Combined infections or no cause | 24 | 32.6 | 22.7 |

Cecil feels that much of the confusion existent with respect to arthritis is due to the lack of a satisfactory classification of the forms of arthritis. He is disposed to accept a classification of arthritis placing rheumatic fever, rheumatoid arthritis and arthritis caused by specific organisms in the infectious group. For the first two of this group, the factor of focal infection is of great etiologic importance, in his opinion. Degenerative arthritis (osteo-arthritis), allergic, metabolic and neurogenic arthritides belong, under this classification, to groups in which the factor of

focal infection is of no or little etiologic importance. Two of Cecil's statements may be reproduced.

> Evidence is rapidly accumulating that rheumatoid arthritis (like rheumatic fever) is a chronic infection. . . . Allergy probably exerts an influence on the disease, but no more than in any other chronic infections. In rheumatoid arthritis a primary focus of infection is the portal of entry for the exciting agent. In respect to its pathogenesis, I consider the disease analogous to gonococcal arthritis, which it often resembles closely. The foci and the infectious agents are different, the mechanism of infection the same.

Pemberton is inclined to be much more conservative in his appraisal of the infection factor than Cecil, from whom I have quoted, Burbank and others, and much more in doubt, as is Jordan. He says:

> The important work of those bacteriologists who have helped to illuminate the doctrine of focal infection has brought out pathologic data and principles of great significance. . . . Bacteriologic workers are, properly, still investigating this field, and the results of further study are to be awaited with interest and expectation, but the arthritic problem as a whole is undergoing its main growth in another direction. . . . The problem of infection, of which so much has properly been heard in recent years, is seen to be in many cases only the precipitating agent, at best. In illustration of this, one need only to ask why the hosts of those harboring focal infection have not all arthritis. Sometimes indeed, possibly often, focal infection is the result of the background rather than the cause of it.

In connection with the last sentence, may I recall an earlier quotation from Lourie and record a similar belief; namely, that focal infection has many of the earmarks of a disease entity and that its etiology is to be found not in any peculiarities of the infecting organisms or organisms, but in the nature and susceptibility of the individual who harbors it.

It would seem that, in the matter of arthritis, and using the phrase already quoted from Jordan, but in an entirely different sense, the situation has provoked a sense of confusion and futility which it is difficult to surmount, and that the only possible position at the present time is to suspend judgment. For the present, in some forms of arthritis, focal infection is still to be considered as an etiologic factor of great importance, although it must be granted that, in many quarters, there is a distinct recession from the advanced position held by the focal infection principle not so long ago. In arthritis, as in iritis, there is this distinct tendency to be less positive as the years go by, both as to the importance of focal infection in the etiology of arthritis and as to the degree of benefit that is to be obtained by its elimination in actual cases of arthritis as a part of the treatment.

In both iritis and arthritis, the statement made by Appleton with reference to tonsillectomy, as far as I know, may be considered to have universal application; namely, that "clinical evidence does not yet seem to have brought out any clear-cut contraindication for the removal of tonsils or adenoids, when there exists well-grounded suspicion that they may serve as foci of infection." Since in many cases elimination of the focus of infection or the foci of infection has been associated with improvement, regardless of the cause of the beneficial effect, there is no indication at the present time of any distinct tendency to limit tooth extractions, tonsillectomies, etc., in the actual treatment of arthritis and iritis.

## TONSILLECTOMY AND THE INCIDENCE OF SUBSEQUENT DISEASE OF FOCAL INFECTION ORIGIN

It has been stated repeatedly that teeth and tonsils are the commonest location of primary foci of infection. On the basis of the figures already quoted for iritis, there is little to bear out this theory as regards the teeth. Tonsil removal has been practiced on such a wholesale scale for so many years that it is possible to study

tonsillectomy as to its effect both in the treatment of focal infection and in its prevention. Although there are no such data on tooth extraction, some attempts have been made to secure similar information.

The teeth and tonsils have many properties in common. They are not highly essential organs; they are easily removed; they furnish a habitat for innumerable bacteria; they are the site very frequently of chronic infections, and they are considered to be the two commonest sources of primary foci in the sense of the focal infection theory. On this account, the effect of the removal of tonsils before the onset of both primary and secondary foci should be somewhat analogous to that of the extraction of teeth before the onset of primary foci. It should be reasonable to assume that extraction of teeth under such conditions will have no more far-reaching beneficial effects than will early tonsillectomy.

The most extensive data of this kind for tonsils have been collected by Kaiser, of Rochester, N. Y., who says, "It was found that growing pains, rheumatic fever, rheumatic carditis and chorea occurred somewhat more frequently in children whose tonsils had not been removed." His data are shown in part in Table 4.

On the other hand, pneumonia, bronchitis and sinusitis are distinctly more common in children who have had tonsillectomy. Other diseases favorably influenced by this operation are: head colds, sore throat, cervical adenitis, otitis media, diphtheria, scarlet fever, nephritis and dental infection. In the last item, dentistry may have some peculiar interest, although Kaiser was inclined to consider it of little material importance. In the middle or neutral list, Kaiser places measles, laryngitis, tuberculosis and malnutrition. The inclusion of malnutrition in this list is rather surprising, and there is some evidence in another report that malnutrition is improved by tonsillectomy.

Kaiser asks:

> What deduction is justifiable from these assembled data? It is at once apparent that tonsillectomy does not remove from children many or in fact any of the usual hazards of childhood. All of the complaints and infections incident to school life are occurring in children who have been operated on as well as those who have not. From this as well as from other controlled studies, it is evident that one must abandon the hope that removal of tonsils and adenoids will radically change a child and confer the type of protection so much desired by it. . . . The real value of the removal of tonsils and adenoids cannot be definitely established in a few years. Apparent benefits during the first few postoperative years are not so evident after a ten year period.

TABLE 4.—KAISER'S DATA

| | Tonsillectomy (2,200 Cases) Per Cent | Controls (2,200 Cases) Per Cent |
|---|---|---|
| Rheumatic fever | 2.3 | 3.5 |
| Growing pains | 7.8 | 9.0 |
| Chorea | 0.6 | 1.1 |
| Rheumatic carditis | 1.1 | 1.3 |

| | Tonsillectomy (28,000 School Children) Per Cent | No tonsillectomy (28,000 School Children) Per Cent |
|---|---|---|
| Rheumatic fever | 1.9 | 3.0 |
| Growing pains | 6.3 | 7.9 |
| Chorea | 0.4 | 0.5 |
| Rheumatic carditis | 2.2 | 2.9 |

A similar study of 12,530 young white women in college was reported by Cunningham. One-third had previously submitted to tonsillectomy, one-third had normal tonsils and one-third had pathologic tonsils. She states:

> The group with normal tonsils and the group with pathological tonsils differ by small percentages, which are statistically insignificant, in the incidence of the following diseases—measles, mumps, chicken pox, whooping cough, scarlet fever, diphtheria, pneumonia, pleurisy, chronic colds, rheumatism, chorea, operations for appendicitis, mastoiditis, cervical glands and operations on the nose. The group with absent tonsils gave a history

of higher incidence of all illnesses and operations than did those with either normal tonsils or the group with pathologic tonsils.

Selkirk and Mitchell report: "We shall content ourselves with the statement that in our study of children three years after tonsillectomy and adenoidectomy there was a lessened incidence of colds, nasal obstruction and sore throats, while sinus infection, headache and growing pains were increased in frequency." The conclusions of Monroe and Volk in a study of nearly 1,500 children are not substantially different from those of Kaiser except that they consider that nutrition is improved after tonsillectomy.

As Kaiser suggests, such figures and data have nothing to do with tonsillectomy in the course of the treatment of individual children. He says:

> Considerable evidence is at hand to convince one of the relationship of infected tonsils to disease in individual children. Removal of tonsils and adenoids in such children has been followed by striking improvement in the child's general condition or by cessation of recurrent infection which has been attributed to the diseased tonsils.

There is little reason to suppose that the routine removal of teeth, even pulpless teeth, as a preventive measure will offer any greater protection in the aggregate against the incidence of secondary disease than will routine tonsillectomy. It is true that there is one valid criticism of this comparison and of the introduction of the matter of tonsillectomy into the argument. All of the data available have to do with comparatively young individuals. Focal infection is largely a condition confined to the later decades of life. Even this difference is difficult to evaluate. One, therefore, is entitled to conclude that tooth extraction is merely a resource in the treatment of the individual case, and even so it has only a limited value. Prevention calls for a different method of approach.

As there are, apparently, no analogous studies for extraction of teeth, it may be permissible to introduce three pieces of evidence that have to do with mouth infection. Appleton states that recruits exhibiting dental disease did not show an undue incidence of arthritis, appendicitis, gastric ulcer, endocarditis, osteitis deformans, myositis or muscular rheumatism. Hyatt was not able to correlate a high incidence of dental infection, in the so-called heavy dentistry group, with any significant medical findings. Arnett and Ennis made routine medical and dental examinations of 883 students of Drexel Institute. With reference to apical infection of teeth, they found that it was frequently associated with albuminuria and underweight, but that this association is not statistically significant. On the other hand, as they say: "It was not associated with rheumatism, chorea and heart disease." They studied 160 young women with the electrocardiograph and were able to bring out no abnormal relationships. In themselves, these studies are without great significance, but analyzed in connection with data presented above concerning tonsillectomy, they have some value, since the conclusions derived from them are of the same general character.

Lourie's cynical comment on this is perhaps pertinent: "If the immortal Voltaire were still on earth, he might be tempted to change his definition of a physician as a man who pours drugs of which he knows little into a body of which he knows less to that of a man who removes tonsils about which he knows little from a body of which he knows less."

### THE PULPLESS TOOTH

While there may be irrelevant and immaterial differences of opinion as to most matters of the dental phase of focal infection, as far as the pulpless tooth is concerned, there are radically opposed schools

of thought. As Appleton aptly says: "The pulpless tooth is in bad repute." One school of thought is engaged primarily in emphasizing its delinquencies and the other in defending its reputation. The subjects of both roentgenography and bacteriology, but chiefly bacteriology, have contributed to the bad reputation of it.

The most extensive and widely quoted roentgenographic study of mouth infection is that made by Black. He showed that apical infection and granulomas, while not confined to pulpless teeth, were much more common in such locations, and that these increased in frequency with age. He was also able to show that such conditions were found more frequently about the apices of teeth that were incompletely filled as seen in the roentgenographic film. Since then, his observations have been repeatedly confirmed.

On the bacteriologic phase, probably the most widely quoted authors in both the medical and the dental literature are Rosenow and Haden. As far as the amount of work is concerned, Rosenow and his pupils have, without doubt, examined more, indeed many more, teeth, than have any other group of workers. On this account there is a disposition in many circles to accept his conclusions without analysis or study of his experimental methods. He has been able by cultural methods to isolate bacteria, mostly streptococci, from all pulpless teeth examined by him, organisms which, when inoculated into rabbits and other experimental animals, produce lesions, and, in many instances, of a very striking and dramatic character. Haden, a pupil of Rosenow, has been able to duplicate these results, although Haden is somewhat more conservative in both his methods and his conclusions, since he has made quantitative studies of both healthy and pulpless teeth, and has accepted as infected pulpless teeth only those in which the quantity of bacteria is greater than that determined for any healthy tooth examined by him. Recently, Rhoades and Dick have offered some studies of the same kind. On the other hand, many authors and workers have failed to corroborate the work just mentioned, or have had just as startling results by the injection of streptococci isolated from the mouths of healthy patients directly into animals. The only possible position to take at the present time seems to be that already suggested by Jordan, to suspend judgment, or to state, as does Appleton, that the pulpless tooth is in bad repute.

All of the bacteriologic workers have severely questioned the reliability of the roentgen rays in examining pulpless teeth, as comparisons between the evidence supplied by bacteriologic examination and that from roentgenograms yield highly contradictory data. Rhoades and Dick conclude on the basis of the data obtained by them from such a comparison:

> In view of quantitative cultures found by Haden and confirmed by us, and the figures just cited, it seems justifiable to regard all pulpless teeth as probable foci of infection whether they show apical changes in the roentgenograms or not. Certainly, this position should be taken in the presence of a disease of the systemic type usually associated with focal infection.

In contrast with this, the figures presented by Skillen are of great interest. He examined the teeth used in his study by histologic methods, preparing sections from all levels of the canal of each tooth so as to fairly sample the condition of the canal throughout. Of 250 roentgen-ray negative teeth so examined, 117 were well filled according to the roentgenogram. On the other hand, of the latter group of 117, only twenty-one were listed as well filled on the basis of the histologic examination. In spite of this form of discrepancy, only six of the whole

number of 250 roentgen-ray negative, pulpless teeth were from the histologic point of view considered to present any evidence of infection. The degree of correspondence between the histologic method and roentgen-ray determination is, therefore, 97 per cent. In the face of such contradictory conclusions one hesitates to accept either as final, and is prone to have more faith in those of the two that agree, namely the histologist and the roentgenographer.

It must be admitted that these histologic examinations have contributed some additional evidence to the bad repute of the pulpless tooth, because the well-filled tooth in every dimension is the exception rather than the rule.

In connection with the discussion of the pulpless tooth, it may be said that too much attention has been paid both to the pulpless tooth and the apical type of infection, especially by physicians; also that, on the whole, the effects of the elimination of apical infection and the pulpless teeth in the routine treatment of focal infection have been disappointing. On the other hand, there has been a tendency to minimize the relationship of the pyorrhea type of dental infection to systemic disease; whereas, I am convinced that the removal of the form of infection found in pyorrhea is almost invariably associated with some visible improvement in the patient's general condition, though it may fall far short of a complete cure.

Another type of dental infection that has received but little consideration, especially from physicians from the standpoint of a primary focus, is the infected vital pulp. Such conditions are too prone to occur under the type of restoration that is becoming more common in order to avoid the necessity of making pulpless teeth. Teeth carrying large inlay and amalgam restorations or crowns over vital pulps are the ones that are likely to succumb to some form of tooth pulp degeneration, and only too frequently these are of an infectious nature. Unfortunately, such infections are prone to become circumscribed and cause but few clinical symptoms or symptoms and signs that are difficult to interpret. As in pyorrhea, their removal is likely to be associated with prompt improvement in the condition of the patient. Thoma, Rickert, Blayney and others have discussed this condition.

## WHAT CAN DENTISTRY OFFER FOR THE PREVENTION OF FOCAL INFECTION?

It must be obvious that if this subject is left as it now stands, the situation becomes one of confusion and futility. It must be just as obvious that the solution that is wholly acceptable is the one and the only one that has proved again and again acceptable in the solution of other medical problems, that of prevention. As far as dentistry and the dental phase of focal infection are concerned, is the technic of prevention to be that of the forceps, as has been so often suggested? I believe that this is not the answer. Is it to be found in technical methods that will obviate the making of pulpless teeth as has already been done by the use of extensive restorations and the placement of crowns and bridge abutments over vital pulps? Again I must register a vigorous no.

Yet it would seem that the last alternative is what Appleton may have had in mind in his conclusion to the symposium on the management of the pulpless tooth. He says:

> While the problem of periapical infection, as a problem in pure biology, is not without its attractions, I am not sure that from a dental or humanitarian standpoint, it is worth the time and money that will have to be spent for its solution. Looking back, my thoughts crystallize into something which sounds like an Irish bull. The only practical solution to

**the problem of the pulpless tooth, I fear, is not to have any pulpless teeth. I do not mean by this that the solution lies in their extraction. That is cutting the Gordian knot. I mean that operative and prosthetic procedures, restorations and appliances should be so designed and carried out that the vitality of the tooth pulp would not be endangered, and—above all—I mean a wider and more energetic application of what we already know about the prevention of dental caries, and the patient careful search after the still elusive causes of this disease.**

It will be seen from this quotation that Appleton is cognizant of the appeal of the forceps solution, but entirely rejects it. He is tempted to emphasize the importance of the second method, that of conserving the pulp, which I believe to be quite superficial and wholly inadequate. But there is a third method which I am sure holds the key to the solution of this problem for those who are willing to take advantage of it. Like Appleton, I feel that the time I have spent in work on the pulpless tooth problem may have been wasted, and certainly as far as the pulpless tooth is concerned, quite sterile in results. On the other hand, if the conclusions that I have reached as the result of that work are sound, it is the most profitable time that I have ever spent.

The solution will, I fear, seem so simple that it will be rejected; just as Osler's receipt for his success in medicine given to his colleagues in Baltimore at the time of his leaving America for Oxford and on the occasion of a small meeting, his secret formula being: W - O - R - K.

The essential features of such a program of prevention, which are not at all new, consist in seeing cases often enough and in the treatment especially of decay as soon as possible after its onset in such a way as to prevent further extension or recurrence in that particular location. The fillings inserted must be of such character as to persist and the cavities must be so prepared as to prevent further extension of the decay process in the tooth. It is also quite obvious that such treatment must be so directed as to protect the soft tissues from infection by preserving contacts, etc. I assume that this is in part what Appleton means by "a wider and more energetic application of what we know about the prevention of dental caries." Certainly it is implied in this statement, although Appleton covers more ground. What I am urging has nothing to do with anything other than the intelligent practice of operative dentistry. Neither do I mean that what is known about diet and nutrition should be neglected nor that we should throw overboard the matter of what goes under the head of dental hygiene. It is my contention that the most efficient weapon that is now available is early recognition and prompt treatment of dental caries.

TABLE 5.—PULPLESS TEETH

| Years | Number | Year | Number |
|---|---|---|---|
| 1901-1905 | 408 | 1926 | 27 |
| 1906-1910 | 352 | 1927 | 17 |
| 1910-1915 | 355 | 1928 | 21 |
| 1916-1920 | 262 | 1929 | 25 |
| 1921-1925 | 155 | 1930 | 13 |
| 1926-1930 | 103 | | |

In this method of attack, involvement of the pulp is prevented, there will be few teeth rendered pulpless and apical infection will therefore be a rarity. Peridental infection will be materially inhibited and mouth infection in the sense of fecal infection will become rare and insignificant.

Such a method of practice management is described by Black in his paper on the "Future Practice of Dentistry," and in this same paper, he presents some data as to the effect this has had on the number of teeth that he has to render pulpless.

He further states: "There has been no change in my attitude on pulp treatment during the last fifteen years, yet the number has been reduced by more than 60 per cent.

Honoroff, in the management of the children at an orphan asylum, has been able to carry the inmates through to the age of 18 or 19, that is, until they are through high school, with only a failure of 2 per cent to attain perfection in this sense. That is, at this age of 18 or 19, they have lost or had rendered pulpless not more than 2 per cent of the permanent teeth.

This plan is essentially implied by Hyatt in his proposal for what he calls prophylactic odontotomy; that is, the elimination of pits and fissures before they are attacked by decay. My reaction to this plan may not be sound, but in my opinion this may be either a blessing or a curse, depending entirely on how it is operated. If it is done without any consideration of what we know about the behavior of caries, it is likely to fail of attaining success.

It would seem that the opportunity to control the development of primary infection is unique as far as the teeth are concerned. Certainly nothing of an analogous character can be done to an organ like the tonsil. Until more is known about such secondary foci, if they be such, as iritis and arthritis, and about the etiology of dental caries, dentistry is in the favorable position of being able to do more in its field to eliminate primary foci than any other specialty of medicine. But it would appear that relatively few practitioners of dentistry have been keen and far sighted enough to take advantage of this situation. There is no promise that the methods that will be developed eventually for the control of caries and focal infection will be any easier to put into operation than the one now at hand for control of decay, pulp involvement and apical infection. May I urge more general adoption of this relatively certain method of preventing a very large proportion of dental infection.

## SUMMARY

There is no reason to assume that focal infection interest is waning, although opinion concerning it tends as time goes on to be both more critical and more conservative. Studies of the prophylactic tonsillectomy cause one to question the value of this operation in preventing the onset of secondary forms of focal infection and, by implication, to question the value of the similar extraction of teeth. The pulpless tooth has gained somewhat of a bad reputation, although, at the present time, there is no reason to assume that all pulpless teeth are infected and good reason to believe that, with proper selection, pulpless teeth are well worth tolerating. Pulpless teeth and primary dental infection can be greatly reduced by a more widespread application of what is known about the treatment of dental caries, so carried out as to prevent pulp involvement and apical infection.

311 East Chicago Avenue.

# STUDIES IN THE INNERVATION OF THE TEETH*

By WILLIAM F. WINDLE, Chicago, Ill.

PERHAPS no subject in dental histology has provoked more controversy than that of the innervation of the teeth. For considerably more than half a century, practical interest has stimulated investigations into the anatomic basis for tooth pain. Much has been written on the subject, but even today our knowledge of the neural mechanisms involved is incomplete and little of it stands unchallenged. Inability to surmount technical difficulties involved in applying neurologic methods to this fascinating study has been a discouraging factor in the past. Uncritical interpretation of results, in some cases by incompetent investigators, has led to considerable misinformation on the subject of tooth innervation.

The peculiarly selective nature of the distribution of sensation in the teeth should make this subject particularly interesting to neurologists because the anatomic basis for pain conduction is receiving active attention at the present time. It is common knowledge that pain is the only sensation elicited by stimulation of the nerve fibers which course within the pulp of the tooth. Some have expressed the opinion that the nerves of the peridental membrane subserve touch or pressure sensation (Black,[1] 1887; Huber,[2] 1898; Allen,[3] 1925). Little is known about the distribution of nerves in this tissue and this subject is beyond the scope of the present paper. Let us examine the mechanism of reception and conduction of pain from the pulp and dentin.

Nearly all investigators agree that each tooth receives bundles of myelinated nerve fibers which enter the root canals and are distributed to various points within the pulp. A few unmyelinated ones are present as the nerve enters the canal, but the largest number possess small sheaths. These fibers vary in diameter between 2 and 10 microns, the majority being 5 or 6 microns (Hopewell-Smith,[4] 1918; Windle,[5] 1927). There are no large myelinated nerve fibers in the pulp of the tooth. It is more than likely that some if not all of the unmyelinated fibers supply smooth muscle of the arterioles in the dental pulp.

*From the Anatomical Laboratory, Northwestern University Medical School. (Contribution No. 187.)

*Read at the Seventy-Fifth Annual Session of the American Dental Association in conjunction with the Chicago Centennial Dental Congress, Aug. 8, 1933.

1. Black, G. V.: Study of Histological Characters of Periosteum and Peridental Membrane, Chicago: W. T. Keener, 1887.

2. Huber, G. C.: Innervation of Tooth Pulp, D. Cosmos, 40:797-811 (Oct.) 1898.

3. Allen, W. F.: Identification of Cells and Fibers Concerned in Innervation of Teeth, J. Comp. Neurol., 39: 325-343, 1925.

4. Hopewell-Smith, Arthur: Normal and Pathological Histology of the Mouth, Philadelphia: P. Blakiston's Son & Co., Vol. 1, chap. 7.

5. Windle, W. F.: Experimental Proof of Types of Neurons That Innervate Tooth Pulp, J. Comp. Neurol., 43:347-356 (June) 1927.

Hopewell-Smith[4] (1918) reported the presence of this type of fiber on arterioles and on capillaries as well. Recent studies by Rogers[6] (1932) and Sandison[7] (1932) indicate that the capillaries in other locations do not possess active contractile mechanisms and they probably receive no efferent sympathetic fibers. It might be suggested that Hopewell-Smith observed precapillaries with fine nerve fibers on them.

The small myelinated nerve fibers and possibly some of the very few unmyelinated ones must be concerned with conduction of painful afferent impulses from the medullary regions of the teeth. This view is in accord with observations on the distribution of pain-conducting fibers in other parts supplied by the trigeminal nerve (Windle,[8] 1926). It likewise coincides with the conclusion of Ranson and his colleagues (Ranson,[9] 1931; Ranson and Davenport,[10] 1931; Davenport and Ranson,[11] 1931), who believe that pain from other parts of the body is conducted by the small nerve fibers, both myelinated and unmyelinated. Heinbecker, Bishop and O'Leary[12] (1933) have presented evidence from electrophysiologic studies that the unmyelinated ones take no demonstrable part and that the small myelinated fibers are predominantly concerned in the phenomenon of pain conduction. They suggest that the unmyelinated nerve fibers which arise in the sensory ganglions may subserve a function of vasodilation. One could hypothesize that the lack of numbers of unmyelinated fibers in the root nerves of the teeth may be correlated with lack of necessity for a vasodilator mechanism in the tooth pulp. Be that as it may, we can safely conclude that small myelinated nerve fibers do conduct painful afferent impulses from the pulp.

What is the nature of the receptive mechanism: the terminations of these myelinated sensory fibers in the teeth? Adrian[13] (1928) has expressed the current opinion of neurologists in regard to pain reception: "It is now believed that there are special receptors and conductors for pain as there are for touch and temperature, but the specific character of pain, its urgency, massiveness, etc., suggests that the receptors and conductors differ considerably from those of other types of cutaneous sensation." Such evidence as is at hand indicates that free nerve endings in the corium, free endings in the cornea of the eye and free endings elsewhere are responsible for pain reception. It is unnecessary for them to reach the surface of the body; they are stimulated through a medium of other nonnervous elements.

In the tooth pulp, highly specialized nerve endings have not been demon-

6. Rogers, J. B.: Observations on Precapillary Cells in Mesenteries of Rabbits, Anat. Rec., 54: 1-7 (Sept. 25) 1932.

7. Sandison, J. C.: Contraction of Blood Vessels and Observations on Circulation in Transparent Chamber in Rabbit's Ear, Anat. Rec., 54: 105-127 (Sept. 25) 1932.

8. Windle, W. F.: Distribution and Probable Significance of Unmyelinated Nerve Fibers in Trigeminal Nerve of Cat, J. Comp. Neurol., 41: 453-477 (Aug.) 1926.

9. Ranson, S. W.: Cutaneous Sensory Fibers and Sensory Conduction, Arch. Neurol. Psychiat., 26: 1122-1140 (Dec.) 1931.

10. Ranson, S. W., and Davenport, Helen K.: Sensory Unmyelinated Fibers in Spinal Nerves, Am. J. Anat., 48: 331-353 (July) 1931.

11. Davenport, H. A., and Ranson, S. W.: Ratios of Cells to Fibers and Myelinated to Unmyelinated Fibers in Spinal Nerve Roots, Am. J. Anat., 49:193-207 (Nov.) 1931. Ranson, S. W.: Anatomy of Nervous System, Philadelphia: W. B. Saunders Co., 1931.

12. Heinbecker, P.; Bishop, G. H., and O'Leary, J.: Pain and Touch Fibers in Peripheral Nerves, Arch. Neurol. & Psychiat., 29: 771-789 (April) 1933.

13. Adrian, F. D.: Basis of Sensation, New York: W. W. Norton & Co., 1928.

strated. The unique descriptions of myelinated nerve fibers entering specialized corpuscles in the hard substance of the teeth (Morgenstern,[14] 1896) are certainly based upon misconceptions. Practically all investigators agree that the pulp nerves break up into a plexus-like arrangement mesiad to the eborial membrane (plexus of Raschkow). As they enter this network, they lose their myelin sheaths and branch freely. A number of critical observers, using thoroughly tested, reliable neurologic methods, have described the free, beaded terminations of these fine branches among the odontoblasts and between the odontoblasts and the dentin. Retzius[15] (1894), Huber[2] (1898), Hopewell-Smith (1917), Walkhoff[16] (1923), Cabrini[17] (1928), Papa[18] (1929), Stewart[19] (1927), Calderón[20] (1930) and Tiegs[21] (1932) are unanimously of the opinion that no significant number of terminals enter the dentinal tubules. In fact, Tiegs (1932) is the only one of them who has observed any nerve fibers in close relationship to the tubules. This investigator found that on rare occasions a fibril may follow an odontoblast process into the opening of a tubule, where it appears to end immediately.

A number of other observers, whose work cannot be placed in the same class with that of Retzius, Huber *et al,* failed to observe endings in dentin. Bödecker[22] (1894) saw fibers ending about odontoblasts and asserted positively that they make indirect connections with these elements. Legros and Magitot[23] (1879) considered the nerve fibers of the pulp to be directly continuous with the central processes of the odontoblasts. Robertson[24] (1891) likewise believed the odontoblasts to be neurosensory cells whose basal processes are directly continuous with the nerve fibers of the dental pulp. A number of others have held similar opinions. In the absence of any proof of these relationships, one cannot accept such heterodox views.

Dissenting opinions in regard to the absence of nerves in the dentin have been held by a number of investigators. There is little or no accord among these workers, and most of their conclusions do not withstand critical analysis. As early as 1868, Boll[25] expressed the belief that

14. Morgenstern, M.: Beitrag zur Kenntniss der Nerven in den Zähnen, Deutsche Monatschr. Zahnheilk., 14: 349-369, 1896.

15. Retzius, G.: Zur Kenntniss der Endingungsweise der Nerven in den Zähnen der Saugethiere, Biol. Unters., 6:64, 1894.

16. Walkhoff, O.: Die Nervenfrage im Zahnbein, Deutsche Zahnheilkunde, 60: 1-43, 1923.

17. Cabrini, A. A.: Beitrag zum Studium der Zahninnervation, Zentralbl. ges Neur. Psychiat., 51:500, 1928. (Original article in Spanish: Revis. Odontol., 1928, No. 5, pp. 255-263, 1928.)

18. Papa, Nicola: Ricerche sulla innervazione della polpa e dello strato odontoblastico nei denti dei mammiferi, Stomatologia, 27: 23-41, 1929.

19. Stewart, D.: Problem of Innervation of Dentine, J. Anat., 61: 439-451 (July) 1927.

20. Calderón, Luis: Contribution à la connaissance de l'innervation des dents, Trav. Lab. Rec. Biol., Madrid., 26: 245-262, 1930.

21. Tiegs, O. W.: Nerve Endings in Human Teeth, J. Anat., 66: 622-627 (July) 1932.

22. Bödecker, C. F. W.: Anatomy and Pathology of Teeth, Philadelphia: S. S. White Dental Mfg. Co., 1894.

23. Legros, C., and Magitot, E.: Morphologie du follicule dentaire chez les vertébrés (note présentée par M. Ch. Robin), Compt. rend. Acad. d. sc., Paris, 88: 615-617, 1879; Contribution à l'étude du développement des dents. Deuxième mémoire. Morphologie du follicule dentaire chez les mammifères, J. de l'Anat. et de la Physiol., Paris, 15: 248-293.

24. Robertson, W. G. A.: Relation of Nerves to Odontoblasts, and Growth of Dentine, Tr. Roy. Soc. (Edinburgh) 36:321-334, 1891.

25. Boll, F.: Untersuchungen über die Zahnpulpa, Arch. mik. Anat., 4:73-87, 1868.

nerves enter the dentinal tubules, and in spite of the fact that he was unable to see them in that location. In 1892, Morgenstern[26] described nerve fibers passing into special canals in the dentin and ending in ellipsoidal bodies. Röse[27] (1893), who saw Morgenstern's preparations, reported that the "nerve endings" were nothing more than processes of the odontoblasts. Later, Morgenstern[26] (1896) described the innervation of the teeth in greater detail. He believed that myelinated fibers pass into the dentin. There can be no question that he was in error, as it has been amply demonstrated that myelin sheaths are lost beneath the subodontoblastic plexus. Römer[28] (1899) claimed to have demonstrated that unmyelinated fibers pass into the interior of the odontoblast processes and run with these into the dentinal tubules. He published but one illustration of this, and we might concede that he did observe one or more in the rare instances when a fibril enters the mouth of a tubule as described by Tiegs[21] (1932). Law[29] (1908), who presents no good evidence, thought he could confirm Römer's results in part. Dependorf[30] (1913) was of the opinion that nerve fibers penetrate the dentinal ground substance; a conception which will not be accepted readily. Fritsch[31] (1914), using the Bielschowsky method, believed he could confirm some of the observations of Dependorf[30] (1913) and Mummery[32] (1912) and part of the criticism of the latter's work may be applied here. It should be pointed out that the Bielschowsky technic is prone to stain fine connective tissue fibers in such a way that one can easily confuse them with fine nerve fibrils.

The numerous writings of Mummery[33] (1924) have, perhaps, contributed more to the uncertainty in our knowledge of the mode of ending of receptor neurones of the teeth than have any of the others. At first, this investigator held the view that the terminations of the pulp nerves pass into the dentinal tubules with the processes of the odontoblasts. He was able to stain numerous fine wavy fibrils in the eborial membrane by means of a technical procedure which is not commonly used to demonstrate nervous tissue and which is probably not at all specific for this tissue. Later, Mummery concluded that the fine fibers which he had seen were not the terminations of the nerves which ramify in the pulp, but were the processes of "nerve-end cells" located in the eborial membrane. These cells, he thought, synapsed with the fibers of the subodontoblastic plexus. The observations of Carol y Montfort[34] (1920,

26. Morgenstern, M.: Vorläufige Mittheilung über das Vorkommen von Nerven in den harten Zahnsubstanzen, Deutsche Monatschr. f. Zahnheilk., 10:436-437, 1892.

27. Röse, C.: Ueber die Nervenendigungen in den Zähnen, Deutsche Monatschr. Zahnheilk., 11: 58-60, 1893.

28. Römer, O.: Nerven im Zahnbein: Zahnistologische Studien, Freiburg.

29. Law, W. J.: Terminations of Nerves in Teeth of Mammalia, Brit. J. Dent. Sc., 51: 481-492, 1908.

30. Dependorf, T.: Beiträge zur Kenntniss der Innervierung der menschlichen Zahnpulpa und des Dentins, Deutsche Monatschr. Zahnheilk., 31: 689-718, 1913.

31. Fritsch, C.: Untersuchungen über den Bau und die Innervierungen des Dentins, Arch. mik. Anat., Part 1, 84:307-320, 1914.

32. Mummery, J. H.: Nerve Supply of Dentine, Proc. Roy. Soc. Med. (London), 5: 166-188, 1912.

33. Mummery, J. H.: Microscopic and General Anatomy of Teeth, Human and Comparative, London: Oxford University Press, 1924.

34. Carol y Montfort, J.: Nerve Cells of Dental Pulp, D. Cosmos, 62:871-874 (July) 1920; La Odontologia, 29:3-8; Researches on Dental Innervation, D. Cosmos, 65:917-937 (Aug.) 1923.

1923) are somewhat similar to those of Mummery, but this investigator added a third element, the "nerve cells of the central pulp," to the already complex picture. Neither the structures seen by Montfort nor those observed by Mummery have the characteristics of true nerve cells, if we may judge by the photomicrographs which they have published.

Furthermore, Stewart[19] (1927) recently took occasion to repeat Mummery's work, using the latter's methods. He was able to demonstrate Mummery's fibers running to the dentin, but he showed by histochemical methods (Mallory's stain) that these are certainly not nerve fibers and are probably a type of connective tissue. The fact that they failed to degenerate after section of the alveolar nerves offers conclusive proof that they are not nerves arising outside the pulp. Stewart was utterly unable to demonstrate the so-called "nerve-end cells" in the pulp. He had the opportunity of consultation with Mummery and was privileged to examine the latter's material. Mummery made the statement to Stewart that he too had had great difficulty in staining "nerve-end cells." He intimated that he had obtained only one satisfactory preparation in thousands of attempts, and that was the only one seen by Stewart. Stewart's work was done in the laboratory of J. S. B. Stopford, who concurs in the interpretations of results and in the conclusion that Mummery had erred.

When the mass of observations, sketched here so briefly, are analyzed carefully, one is led to agree with Retzius[15] (1894), Huber[2] (1898), Walkhoff[16] (1923), Calderón[20] (1930) and a few others whose methods we know to be sound that the sensory pulp nerves end freely about the odontoblasts and between these cells and the dentin and do not, except possibly on rare occasions, as Tiegs (1932) found, pass into the dentinal tubules.

To debate the question as to how these free nerve endings are stimulated, whether by pressure on the fluid contents of the dentinal tubules as suggested by Gysi[35] (1900) or by actual conduction over the odontoblast processes (Hopewell-Smith, 1918; Pont,[36] 1900; Fischer,[37] 1909; Hoehl,[38] 1896) would carry us too far into the realm of speculation. It is sufficient to observe that, whatever the stimulus, be it heat, cold or pressure, the only sensation experienced is one of pain.

In the case of the tooth pulp, as in that of the cornea of the eye, painful stimuli are received by free nerve endings. We know that they are conducted over small myelinated nerve fibers. With these facts well established, we are able to proceed to a determination of the type of nerve cell from which the pain conducting fibers arise. We know that, in the spinal nerves, the unmyelinated and probably the small myelinated nerve fibers arise from the smaller cells of the dorsal root ganglions (Ranson,[39] 1931) and, as previously stated, we respect the evidence that one or both types of fiber may be concerned with pain conduction. The question then arises: Do the small cells

35. Gysi, Alfred: Attempt to Explain Sensitiveness of Dentine, Brit. J. D. Sc., 43: 685-688, 1900.

36. Pont, A.: La Cataphorèse en Art Dentaire et Plus Spécialement dans les Cas de Dentine Hypersensible, Tr. Third Internat. D. Cong., 1900, p. 232.

37. Fischer, G.: Bau und Entwicklung der Mundhöhle des Menschen, Leipsic: W. Klinkhardt, 1909.

38. Hoehl, E.: Beitrag zur Histologie der Pulpa und des Dentins, Arch. Anat. Physiol., Anat. Abt., 1896, pp. 31-54.

39. Ranson, S. W.: Anatomy of Nervous System, Philadelphia: W. B. Saunders Co., 1931.

of the semilunar ganglion give rise to the pain conducting fibers of the tooth pulp?

After removal of teeth, Spitzer[40] (1910), Perna [41] (1913) and Allen[3] (1925) observed that all types and sizes of nerve cells in the semilunar ganglion undergo chromatolysis. This does not mean that the small pulp nerves arise from all sizes of nerve cells. More than the pulp was destroyed when the teeth were extracted. The nerves of the peridental membrane must have been interrupted and the alveolar nerves themselves may have received injury. In a series of five cats and one dog, I[5] extracted the pulps, without otherwise disturbing the teeth, in all except the incisor teeth on one side of both jaws. After time had been allowed for the axone reaction to take place, the semilunar ganglions were prepared by the toluidin blue method and examined for alterations. No significant number of chromatolyzed large cells (i.e., more than 30 microns in diameter) resulted from these operations, but many of the cells less than 30 microns in diameter did undergo chromatolysis. Since the small cells normally show irregular arrangements of chromatic substance, I did not count any except those which exhibited a marked reaction. Nevertheless, a distinct difference between operated and control sides could be observed. Therefore, it may be concluded that the pain conducting fibers which supply the tooth pulp arise from cells of the semilunar ganglion which are less than 30 per cent in diameter. The fibers are predominantly small myelinated ones, and they end in the eborial membrane beneath the dentin in free, beaded terminations.

40. Spitzer, B.: Die Veränderung des Ganglion des Gasseri nach Zahnverlust, Arb. neur. Inst. Wien. Univ., 18: 216-227, 1910.

41. Perna, A.: Sulle alterazioni del ganglio die Gasser in seguito all'avulsione dei denti, Ric. Lab. Anat. Norm. R. Univ. Roma, 17: 81-105, 1913.

# MUTILATED GROWTH*

By T. WINGATE TODD, Cleveland, Ohio

## VARIABILITY IN GROWTH

A STUDY of developmental growth must start by determinations made on individuals. For precision of observation, this means measurement. The problem of how to measure is second in importance to that of what to measure, for though each of us has his own special interest in developmental growth localized in some particular part of the human organism, we all know quite well that the particular part which holds our special interest is but a part after all of the entire organism and cannot be fully or satisfactorily understood unless our information is broader than our specific quest. We shall indeed feel confident of the value of our observations only as far as they facilitate understanding of developmental growth evident in the whole

*From Western Reserve University and the Brush Foundation.

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human organism. But that is a large order. It is impossible for one man, no matter how intense his enthusiasm or how broad his interest, to encompass the entire subject of developmental growth. Integration of studies is essential. This implies teamwork, and since most of us must endeavor to solve our problems without the advantage of actual cooperation with other workers in other disciplines, some common agreement on principles of investigation is necessary to secure effective integration. It is my good fortune that I do not work alone, but in the company of numerous investigators on diverse aspects of our common problem, so that the observations which I am about to set before you are derived from the cooperative studies of many eager and thoughtful workers each contributing his quota to our united effort.

I was saying that investigation of developmental growth starts with the measurement of individuals, but since these individuals themselves differ in their potentiality and expression of developmental growth, we must assemble our data so that they reflect or at least check with developmental growth of the population. This implies statistical reduction, which is of practical service only as long as the figures by which we express our observations represent actual fact.

An average is of little use if it does not express the usual—I would not say normal—manifestation of the trait that we are measuring. Individuals vary in their deviation from the usual or modal valuation of the trait measured. The variability can be expressed by a statistical convention as a percentage of the average or mean value. This statistical convention is known as the coefficient of variation. Some years ago, when Miss Lindala and I were appraising the variability in dimensions of different parts of the body, I was surprised to find that variability depends less on the magnitude of the dimension than on the part of the body measured.[1] There is a great difference in numerical value between head length and leg length, but each dimension is the measurement of an entire unit of the body and their variabilities are similar. Major portions of these units, say facial depth and thigh length, show a similar though greater variability. Smaller portions, again, show a common, though still more increased, variability. This pattern of variability is really a statistical expression of symmetry.

I am not going to explore this obscure subject of bodily symmetry, which we recognize more in the breach than in the observance, but I wish to point out that the growth of a part, carefully chosen, can illustrate, since it bears a definite relation to, the growth of the body.

## THE CHARACTERS OF DIMENSIONAL GROWTH

One of my younger colleagues in this investigation, Mr. W. B. Seymour, has lately been studying growth in the limb bones, the most readily studied of which is the tibia. A hundred and fifty years ago, John Hunter studied the growth of limb bones by two very different methods. At first, he cut down on the bone and inserted pellets in the shaft. After allowing the animal to recover from the operation and to live some time, he measured the distance between the pellets and found it unchanged, although the

1. Todd, T. W., and Lindala, A.: Dimensions of Body: Whites and American Negroes of Both Sexes, Am. J. Phys. Anthropol., 12: 35-119, 1928.

bone itself was longer. Clearly, growth in length occurs at the ends of the shaft. The other method utilized the staining power of madder on living bones. Seymour clearly must adopt a method quite different from these two for determination of growth in the bones of living children.

Fortunately, Nature provides us with landmarks for the registration of growth. A child who suffers a sudden and temporary inhibition of growth bears the mark of this inhibition for some time, usually a few years, in the form of a more or less clearly defined transverse line—a sort of scar—on the bone. These scars are left as relics of high fever, of acute dietetic disorder, of a severe attack of measles, whoopingcough or other childhood disease, or indeed of any sudden disturbance in the course of developmental growth such as that induced by a surgical operation with its associated anesthetic. As the bone grows after the interruption, the line or scar recedes from the growing end and ultimately fades away. But, until this happens, an opportunity is given us of measuring the increment and velocity of growth. The tibia is a particularly useful bone for our immediate purpose since both ends grow, and both, being subcutaneous, are accurately measurable on roentgenograms.

Now the amount of growth depends on the site, the length of time and the growth velocity. There is no interstitial growth in bone although the shaft does undergo remodeling: growth is limited to the ends of the shaft at the diaphyso-epiphysial planes. Growth energy fades out a year or two before the diaphyso-epiphysial plane is obliterated by union of the epiphysis with the shaft. Exceptionally, in limb bones, but quite commonly in skull sutures, the corollary of terminated growth, namely, union, fails to take place. I have termed this condition lapsed union.[2]

Velocity of growth depends on health of body and interaction of endocrine glands. When Seymour started his work, we imagined that the velocity of growth would vary with the age and sex of the child. Seymour examined the serial roentgenograms of 3,200 children, the films having been made at intervals of a year or less. Among these, he found thirty-one children whose bones showed the scars of interrupted development. We now learned, to our surprise, that while the bone is actively growing, its velocity of growth is so nearly constant that we could not discern the fluctuations. The problem of growth, therefore, is simpler than we had anticipated. Modifications of velocity in growth are negligible. The bone is either resting or growing at a rather definite and uniform velocity.

That there is a clearly expressed periodicity of growth in children needs no emphasis. It has been recorded beautifully in Davenport's elaborate studies.[3] There is a spurt of growth, for example, between 6 and 8 years, a slump between 9 and 13, and another spurt between 14 and 15 years, followed by a slump before its complete cessation and subsequent union of the epiphyses.

A similar periodicity has been demonstrated by Hellman in growth of the

2. Todd, T. W., and Lyon, D. W., Jr.: Endocranial Suture Closure; Its Progress and Age Relationship. Part I. Adult Males of White Stock, Am. J. Phys. Anthropol., 7: 325-384, 1924.

3. Davenport, C. B.; Physical Growth in Second Decade. Proceedings Conference on Adolescence, Brush Foundation, Cleveland, pp. 5-19, 1930.

face.[4] Anteroposterior growth is most intense in its activity during the first seven years of life. Between 7 and 15 years, the most active growth occurs in transverse and vertical directions. From 15 years onward, there is a sort of residual growth in girls, but a longer continued growth in boys involving all three dimensions though mainly expressed in vertical and transverse measurements. It follows from this that the interruption or inhibition of growth during infancy and early childhood will interfere more with anteroposterior facial growth than with increase in vertical or transverse dimensions.

### FEATURES OF DEVELOPMENTAL MATURATION

Developmental growth implies maturation as well as growth; and these two processes do not necessarily proceed at an equal rate. Maturation seems to be less dependent than growth on the delicate balance of health. A child too sick to grow will still show the regular progress in maturation. In the present state of our knowledge, it is somewhat dangerous to make arbitrary assumptions, but, in a very general way, it may be hazarded that vitamins are specially responsible for bodily health, that mineral metabolism controls functional efficiency and that the thyroid gland is more intimately related to growth and the pituitary or hypophysis to maturation. The gonads perform a very special function in maturation and, as far as the other so-called endocrine glands are concerned, we have too little information regarding them to warrant even so tentative a suggestion of relationship to developmental growth.

It is important to realize how the mental and emotional responses, which together make up the behavior pattern, are as definitely expressive of developmental growth as the more tangible bodily changes. I can illustrate this by reference to a child whose progress I have been studying for the past year. SS 3125, in our Brush series, is a girl seen first at 3 months of age when the height was low and the weight very low for the age. The child was entirely breast fed for three months and some cod liver oil was administered daily. At 3.5 months, S. M.A. was substituted for the breast milk and there was a stormy period of adjustment, with dyspepsia, diarrhea and anorexia followed by nasopharyngitis. Cereals, vegetables and broth were added to the diet, with haliver oil and viosterol. At 6 months, the height had come up to the average, but the weight and mineral rating on epiphysial ossification remained very low. The muscular power and control were improved and the personality traits remained high as they had always been. Anorexia continued, with foul stools. The condition was combated with Mead's yeast, calcium lactate, ferrous carbonate and Parke Davis' vitamin B extract. The haliver oil and viosterol were omitted. At 9 months the height was normal, the weight very low, the mineral balance in epiphysial ossification very high, and a commencing debilitation was indicated by lowered muscular power and diminished personal trait and social response ratings.

Class I milk was now substituted for S.M.A., but nasopharyngitis and diarrhea persisted till 12 months. Then the appetite returned, the stools became firm

4. Hellman, Milo: Eruption of Permanent Teeth and Accompanying Facial Changes, Proceedings Conference on Adolescence, Brush Foundation, Cleveland, pp. 28-35, 1930.

and the locking up of lime and phosphorus in the depots ceased. The child began to improve.

It was from the study of children carried on in the manner just described that we learned the true significance of the dates of epiphysial ossification. With the successive months of infancy, ossification occurs in fresh sheaves of centers. A time-table can be constructed. If the child suffers from difficulties in adjustment to diet, from gastro-intestinal disorder or infectious disease, ossification is delayed and muscular debility indicates a lack of mobile calcium in the body. Administration of vitamin D first increases muscular power and next accelerates ossification. But if the dose of vitamin D is pushed, the acceleration in ossification may become very marked and muscular debility again set in, apparently because the calcium, which should be mobile, becomes locked up in the skeletal depots. It can be unlocked again by simply stopping the vitamin D administration.

With the continued gastro-intestinal disorder, growth of the body, and especially of the face, is diminished in velocity. Since it is the anteroposterior facial growth which should be most vigorous at this period, it is in the anteroposterior dimension that the diminished growth is most clearly observed.

The lesson we learned from children, like the one just quoted, is that interruption of developmental growth by disease or debility is nonspecific. The particular expression of developmental growth is inhibited, which is characteristic of the period when the disorder happens to strike. During and after convalescence, one of two courses must be taken. Either the development growth previously inhibited must renew its activity with increased velocity or adjustments must be made in the now mutilated pattern of development growth. Nature, as it were, is seeking to distribute the load.

## EXPERIMENTAL GROWTH MODIFICATION

At this point I must digress from the consideration of human growth in order to present a little experimental evidence on interrupted growth.

In a former communication,[5] I pointed out that thyroidectomy in sheep at 1 month of age induces a profound growth defect which is characteristic of the date of interruption and not of the form of interruption.

Wharton, in my laboratory, studied the growth pattern of the normal sheep face and contrasted it with that of the twin sheep from which the thyroid gland was removed at 1 month of age but the parathyroid glands were left intact. For a period thereafter, all growth processes are impeded, but since anteroposterior growth of the upper jaw is characteristic of the early months in the sheep's life, it is in the anteroposterior facial dimension that we find the most marked interruption. An interesting and significant feature of these studies is that administration of thyroxin sufficient to restore the animal functionally will not repair the defective facial growth, which is permanently mutilated. Adjustments, of course, take place, but the anterior part of the face, namely the muzzle and the nose, remains small. The animal usually dies of respiratory disorder before it is 2 years old; but if it survives, the uninterrupted mandibular growth produces an obviously overshot jaw.

5. Todd, T. W.: Hereditary and Environmental Factors in Facial Development, Internat. J. Orthodontia, 18:799-808 (Aug.) 1932.

It is the nonspecificity of interruption in developmental growth which makes the analysis of cases at once so puzzling and so fascinating. Dwarfism, for example, occurred equally in Sutherland Simpson's thyroidectomized lambs and Aschner's hypophysectomized puppies, but the manner of inducement of dwarfism though indirect in both, was widely different in the two series of experiments.

### THE ANALYSIS AND CONTROL OF INTERRUPTED GROWTH

While we were pondering over the defects in growth which crowded on our attention, one of my assistants, Mr. Venar, planned and carried into execution a long and careful series of biologic assays on the experimental modification of calcification in growing bones. He used for this purpose the tibia and femur of rats fed a rickets-inducing diet. The experiments on calcification *in vitro* were carried out with elaborate precautions. They were based on the well-established fact that such bones, while very deficient in lime, are avid for calcium provided it is available in utilizable form. If the rachitic bone is immersed in a basal solution containing inorganic calcium, avid though the cartilaginous and osteoid tissue unquestionably is, it will not calcify. If organic calcium is provided, the tissue calcifies at once. The addition of various substances to the solution containing the rachitic bone enables us to study the influence of these substances on calcification. Venar's observations will shortly be ready for publication, and it would ill-become me to describe them in advance; but I am able to demonstrate in this address the reinforcing action of thyroid extract, the regulating influence of pituitary extract and the powerful stimulating effect of the sex hormones in these calcification studies.

When the public began to learn the extent of our studies, the demand grew insistent that we put them to practical service and, in response to this insistence, Dr. Zuck and I commenced very cautiously and conservatively to study the effect of endocrine administration on children retarded in developmental growth. I put the entire clinical supervision in Dr. Zuck's hands and devoted myself to the analysis of the defect and to the assessment of progress under Dr. Zuck's administration of the substances. No case has ever been undertaken except after the parents have been taken fully into confidence concerning the state of knowledge on the subject and the need for constant care and observation.

Now it would be, in my opinion, quite unjustifiable to undertake such interference but for two facts which we have been able to establish. The one is the nonspecificity of growth disturbance to which I have referred above. The other is a most significant instrument which has been given to medical diagnosis as the result of a quarter of a century's persistent and unremitting labor in my laboratory; namely, the power to assess accurately and quantitatively the effect of interference in the developmental growth pattern. This is done by roentgenographing the several growing limb bones and comparing their stage of maturity, not of growth, with standards which have been established by the examination and analysis of many thousands of children and growing mammals. I have recently described the technic and principles of assessment[6] and will therefore merely

6. Todd, T. W.: Roentgenographic Appraisement and Developmental Growth in Skeleton. In Growth and Development of the Child. Part IV Appraisement of the Child. Reports White House Conference on Child Health and Protection, New York, 1932, pp. 258-285.

allude to these in passing. By a standardized technic, the roentgenograms are always comparable. The principle underlying the assessment is that skeletal maturation progresses strictly with bodily maturation, of which it is an index, and can be assessed by the pattern of osseous penetration of the epiphysial and diaphyso-epiphysial cartilage. A general statement of the whole subject has been published.[7]

Many other medical men have attempted to utilize endocrine substances. They have met with varying, uncertain and often disappointing results. But this is because they were unable to assess the effect or control progress. Dr. Zuck's successful efforts have been due entirely to the fact that he and I working together are no longer uncertain of the condition which we are attacking or of the progress which we are making.

It may be objected that these attempts should first be carried out on animals. My response is that, if experimentation is properly controlled, there is no longer the possibility of making the patients' condition worse and that the only mammals even approximately adequate for the purpose are the great anthropoids, the strength and intractability of which as they grow to the period of life when they would be most useful renders them quite unsuitable. I will therefore demonstrate to you the course of a single typical case under treatment.

SS 2895 is a boy whom we saw first in May, 1931, when he was 15 years and 4 months old. He was short and stocky with a dry and somewhat roughened skin, marked pudginess of subcutaneous tissue, a dry scalp with dry sparse and rather brittle hair, a somewhat set expression, a stolid springless gait, a childlike voice and no sexual hair. At that time, his height was equivalent to 8 years 8 months and his weight to 11 years 6 months on the Baldwin Wood standards, while the roentgenograms gave him a physical developmental rating erratically expressed in different parts of the body from 10 to 9 years. The second molars were not yet fully erupted. The boy had hematuria, his basal metabolism rate was minus 19 and his facial growth greatly retarded.

After two months' treatment, his weight was reduced by 10 pounds, his subcutaneous edema diminished, and his skin became moist and his hair lustrous.

After five months' treatment, he had grown the equivalent of ten months and, in physical development, he had progressed the value of twelve months.

In order to be sure that he was actually speeding up growth, Dr. Zuck continued the treatment as before for another three months. This resulted in a further growth equivalent again to ten months and a physical development of another fifteen months.

Lest physical development outrun growth, Dr. Zuck now changed his treatment, with the consequence that, during the next three months, height increased the value of ten months but physical development was negligible.

This treatment was therefore continued for a further period of three months. It again resulted in growth equivalent to ten months and negligible physical development.

During the fourteen months covered by this statement, height had been increased to the value of forty months and

7. Todd, T. W.: Comparative Youth; Physical Aspect. Child Development, 1: 79-89, 1930; Anatomical Features of Epiphysial Union, ibid., 1: 186-194, 1930; Roentgenographic Appraisement of Skeletal Differentiation, ibid., 1: 298-310, 1930; Differential Skeletal Maturation in Relation to Sex, Race, Variability and Disease, ibid., 2: 49-65, 1931.

physical development to the value of twenty-seven months. The boy now had a height equivalent to 12 years 0 months, a weight of 12 years 2 months and a physical development of 13 years 0 months. His voice was deepening, his sexual hair characteristic of commencing adolescence and his I. Q. had risen from 94 to 102. At the same time, his face had grown and matured correspondingly.

I will say no more about this boy, for Dr. Zuck intends to publish the records in full along with those of others, but I do want to direct attention to the possibilities of restorative treatment and more particularly to the practical possibilities of influencing favorably the progress of facial growth.

### ORTHODONTIC SIGNIFICANCE OF MUTILATED GROWTH

Now that I have sketched the general course of our studies on developmental growth I must take, as a concrete example, the mutilation of normal facial growth which is so significant in orthodontia and restorative dentistry. The information which I have on this subject is of course based upon the brilliant and accurate studies of my colleague, Dr. Broadbent, and his able group of coworkers, made possible, through the Bolton Study, by the generosity of Mrs. Chester C. Bolton and her son, Mr. Charles Bingham Bolton. I think it is fair to claim that dental science is forever under obligation to the Boltons for one of the most outstanding contributions to professional progress which the history of dentistry affords. For the details of the technic by which developmental growth in the face is accurately measured, I must refer you to Broadbent's published description.[8]

As long as we were able only to measure the dead skull, we were defeated in our efforts to portray facial growth, for the dead child is necessarily an example of defective growth, unless, indeed, the child has been killed while in full health or struck down by a rapid toxemia like that of pneumonia or burns. I have referred to this subject in a short paper recently printed[9] and need but recall the point to your attention.

Instead of reviewing our findings on this subject, to which indeed I have already alluded in this address, I will present the course of facial development in an infant suffering from a growth handicap through chronic gastro-intestinal disorder. The clinical history is the following.

SS 3130, a boy, was first seen in August, 1931, when he was 3 months old. Being unable to nurse him adequately, his mother supplemented the nursings with S.M.A., finally weaning the child at 6 weeks. Adjustment to a foreign protein was difficult and expressed itself in green and mucous stools. At 3 months, the height and weight were a little low; the calcium balance estimated from the roentgenograms was quite unsatisfactory, but muscular strength and control and the social responses were appropriate to the age, so that the child appeared healthy and normal despite the gastro-intestinal disturbance.

Our apprehensions were confirmed by the onset of repeated pharyngitis and otitis media from 4 months.

When we saw the child at 6 months, his height, muscular control and social responses were satisfactory but his weight was quite low, his muscular strength disproportionately low for his muscular con-

8. Broadbent, B. H.: New X-ray Technique and Its Application to Orthodontia, Angle Orthodontist, 1: 45-66, 1931.

9. Todd, T. W.: Orthodontic Value of Research and Observations in Developmental Growth of Face, Angle Orthodontist, 1: 67-79, 1931.

trol and his calcium balance scarcely changed from what it had been three months before. Nevertheless, his face appeared full and well nourished and his attitude was still serene. The physician had commenced viosterol therapy at 5.5 months, and our fears were still discounted.

The next three months, under vitamin D treatment, were clinically uneventful, but the condition at 9 months of age dismayed us. The stimulating effect of vitamin D was evident in the muscular power, but debility was evident in the social traits. Growth had been inadequate. Weight was very low and the calcium balance remained unchanged. The child had not had enough vitamin D to build up his lime reserve. The face now showed clearly the lack of growth in the anteroposterior dimension, and Dr. Broadbent proved that no growth whatever had taken place in this facial dimension since the child was 3 months old.

The viosterol treatment ceased at 8 months. When we saw the child at 12 months of age, he had all the signs of a marked debility. His face was thin, pinched and unnaturally old. His expression was haggard. He was restless, querulous and unattractive. Stature and weight were far below average and calcium balance was almost dangerously reduced. A fresh siege of persistent diarrhea had lasted for a month; but there were signs of restoration in a renewed slight anteroposterior facial growth. Energetic vitamin treatment is now repairing the havoc which might have been averted had the warning been heeded in time. Whether adequate reconstruction of facial growth will ultimately occur is a matter for future determination.

Children of this type characteristically start with infantile gastro-intestinal debility and progress to facial maldevelopment in very early childhood. Owing to restricted growth of the nasopharynx, they come to the ear, nose and throat specialist for removal of adenoids to clear the narrowed passages, then to the orthodontist for spacing of crowded teeth in underdeveloped jaws, and they finally threaten the child guidance clinic because of behavior difficulties. The problem of nutrition becomes first a medical then successively a surgical, a dental, a psychologic and perhaps ultimately a social problem. Diet and nutrition are our first defense against the debility which precedes defect.

## RÔLE OF NUTRITION IN RESTORATIVE DENTISTRY

In closing, let me refer to the efforts of Weston A. Price in prophylaxis against just such mutilations of facial growth as that which I have described. Dr. Price has emphasized the necessity of a diet containing not only a sufficient amount of protein, carbohydrate and fat for effective tissue-building and energy-production but also an adequate mineral and vitamin content to promote the health and efficiency of body and mind which we all demand for the children of this nation. Neither medicine nor dentistry is any longer content with corrective treatment: nothing less than restorative and protective measures will satisfy us in the future.

## SUMMARY

1. The study of developmental growth demonstrates, by analysis, that growth and maturation may be dissociated.

2. Principles of growth are becoming simplified through intensive study by accurate technic and its adequate control is already coming within our competence.

3. Facial developmental growth can be analyzed and its progress determined with exactitude.

4. Facial maldevelopment is characteristic of infantile disorders involving nutritional defects and its prevention is a part of a positive health program in the early months of life.

5. Restorative dentistry, like restorative medicine, must call diet and nutrition to its aid, and supervision of facial and dental developmental growth must be instituted from early infancy if the imperfect reconstruction of corrective measures is to be forestalled.

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# THE MINUTE ANATOMY OF THE DENTURE BEARING AREA*

By ELBERT C. PENDLETON, M.D.S., Chicago, Ill.

THE tissue changes which occur in the mouths of those wearing complete artificial dentures is a topic of considerable discussion in prosthetic circles. The altered form and character of the structures of the jaws have an intimate relation to the retention of the artificial appliance and to the comfort and the satisfaction experienced by the edentulous individual.

Research investigations relative to the cause and effect of these changes have been of a clinical nature, with the exception of that done by Brinch,[1] Grohs,[2] Mentz[3] and Wright,[4] who have made histologic studies of tissue sections from the mouths of persons wearing artificial dentures.

More pertinent to the study of retention and the development of a successful method of treating the edentulous condition is a fundamental knowledge of the structures of the jaws as they exist in the normal state. With such a background, the prosthetist may hope to avoid those methods of practice which are accountable for inflammatory reactions within the soft tissues.

This report of the continued investigations in the minute anatomy of the denture supporting areas includes a study of two upper and four lower jaws. One of the upper jaws was from the cadaver of a man, aged 62; the other from a woman, aged 51. Two of the lower jaws were from men and the others were from women. The men were 62 and 80;

*From the Research Department (Rudolf Kronfeld, director) of the Chicago College of Dental Surgery, Dental Department of Loyola University.

*Read at the Seventy-Fifth Annual Session of the American Dental Association in conjunction with the Chicago Centennial Dental Congress, Aug. 8, 1933.

1. Brinch, Ove: Histologische Untersuchungen über pathologischanatomische Veränderungen im Gaumengewebe prothesentragender Patienten, Vierteljahrsschr. f. Zahnheilk., 48: 120, 1932.

2. Grohs, Richard: Anatomisch-histologische Grundlagen zum Aufbau einer totalen prothese mit besonderer Berückschtigung des Abdruckverfahrens, Ztschr. f. Stomatol., 29: 675 (May) 1931.

3. Mentz, E.: Histologische Untersuchungen über den Bau der Mundschleimhaut und ihre Beziehungen zum Zahnersatz, Deutsche Monat. f. Zahnheilk., 49: 66, 1931.

4. Wright, W. H., Morphological Changes in Mucous Membrane Covering Edentulous Areas of Alveolar Process in Human Mouth, J. D. Res. 13: 159-160 (April) 1933.

the women, 51 and 58 years, respectively.

Up to this time, serial sections from five upper and four lower jaws from persons ranging from 38 to 80 years of age have been examined microscopically in order to verify the early findings established by this study.

Specimens of edentulous and partially edentulous human jaws were secured soon after death and fixed in 10 per cent formalin and alcohol. In the preparation of this material for study, they were first decalcified in 5 per cent nitric acid, then imbedded in celloidin and cut into serial sections of from 25 to 30 microns thickness. The sections were stained with hematoxylin and eosin.[5] The jaws were sectioned in several directions to permit the study of each region, and the various regions were studied according to the anatomic location of the natural teeth. It was thought that, by such a plan of study, a better understanding of the structures might be obtained.[6]

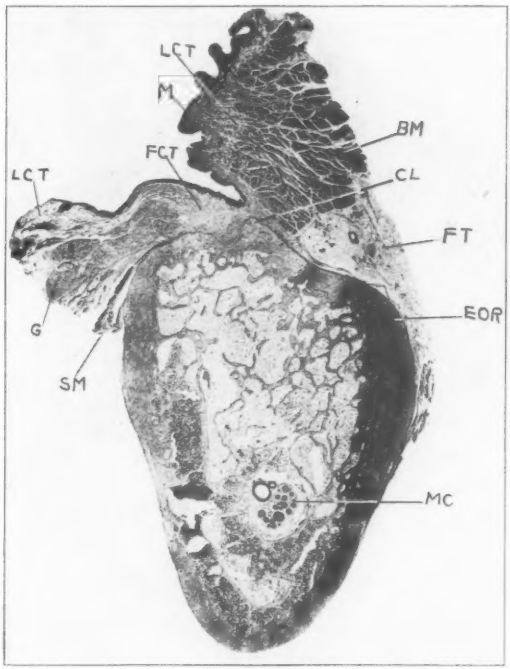


Fig. 1.—Buccolingual section in retromolar region of lower jaw from woman, aged 51. *G,* retromolar glands; *LCT,* loose connective tissue; *FCT,* fibrous connective tissue; *M,* mucosa of cheek; *BM,* buccinator muscle; *FT,* fat tissue; *EOR,* external oblique ridge; *MC,* mandibular canal; *SM,* superior constrictor muscle; *CL,* lateral crus of temporal crest.

5. Krönfeld, Rudolf: Histopathology of the Teeth and Their Surrounding Structures, Philadelphia: Lea and Febiger, 1933, pp. 460-469.

6. Black, G. V.: Descriptive Anatomy of the Human Teeth, Ed. 4, Philadelphia: S. S. White Dental Mfg. Co., 1920, pp. 14-31.

In order that the topographic form of the denture area might be studied, a clinical examination was made of the mouths of many edentulous patients. Impressions of these mouths were taken, casts were obtained and divided into regions according to the distribution of the hard and soft tissues and the clinical findings were supplemented by microscopic examination of tissue sections of the edentulous jaws.

Many, if not all, of the facts disclosed by the microscopic studies are known, but have been poorly appreciated by the student of complete denture prosthesis. These studies have been correlated with the clinical phases, that they may be more readily understood and, what is of still greater importance, they emphasize their application to the problem of retention.

It is indeed significant that there exists a marked consistency in the type, location, and distribution of the tissues found in each section, although the structures vary greatly in character in the different regions of both the upper and the lower jaw.

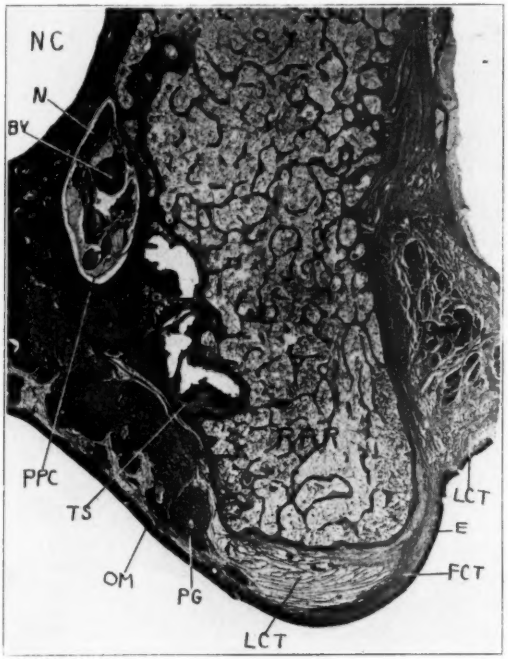


Fig. 2.—Frontal section through upper jaw of man, aged 38, in region of pterygopalatine canal and posterior extremity of maxillary tuberosity. *PPC,* pterygopalatine canal; *NC,* nasal cavity; *PG,* mucous glands of palate; *BM,* buccinator muscle; *LCT,* loose connective tissue; *OM,* oral mucosa; *TS,* transverse suture uniting maxilla and palatine bones; *BV,* blood vessels; *N,* anterior palatine nerve; *RAR,* residual alveolar ridge; *E,* epithelium.

The study of the later specimens has

greatly broadened the conception of the manner in which Nature carries out her scheme in building the human framework. It reflects the superlative plan to coordinate the structures to withstand the normal functional stresses and to so build the larger parts as to reduce their weight. The delicate organs are so placed that their protection is assured and the units are so assembled that the whole of this complex mechanism is one of fascinating symmetry, drawing the student with an irresistible charm to delve into its intricacies.

The gross anatomy of the jaws is well understood by students of prosthesis; but only within recent years has a study of the minute structures found practical application in the field of complete denture construction.

Since my first report[7] of this study, which was presented before the International Association for Dental Research at its meeting in Memphis in March, 1931, it is evident that a considerable interest has developed in the biologic phases of retention. Several workers have entered the field, but as far as is known, no further reports have been recorded.

A study of the biologic factors discloses their intimate relation to the clinical phases of retention that are of particular significance in complete denture prosthesis. The musculature and the mucosa are structures most pertinent to this work.

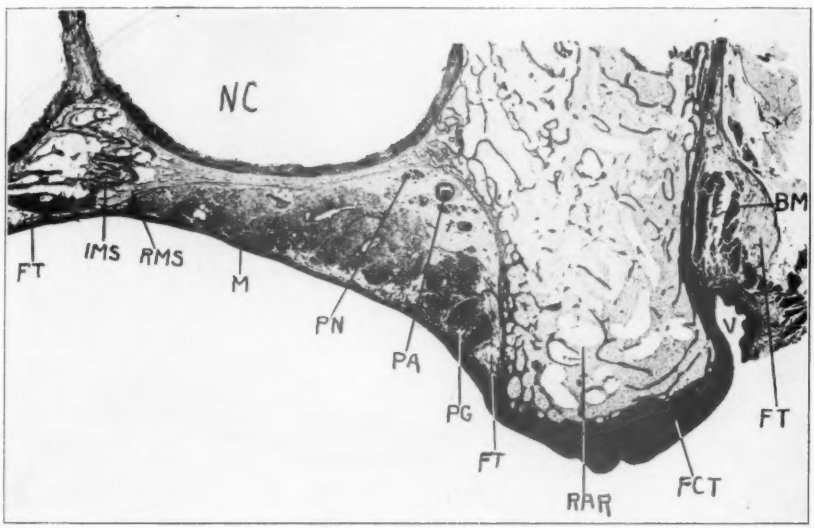


Fig. 3.—Frontal section from molar region of upper jaw of woman, aged 51. *NC,* nasal cavity; *FT,* fat tissue; *IMS,* intermaxillary suture; *RMS,* ridge of maxillary suture; *PN,* palatine nerve; *PA,* palatine artery; *G,* palatine glands; *RAR,* residual alveolar ridge; *FCT,* fibrous connective tissue; *BM,* buccinator muscle, *V,* vestibulum; *M,* mucosa.

7. Pendleton, E. C.: Histologic Study of Soft and Hard Tissue of Edentulous Maxilla, and Their Relation to Problem of Full Denture Retention, J. D. Res., 11: 490 (June) 1931.

Throughout the various regions of the jaws, these structures are distributed with definite regularity, and it is their quality and location that affects the permanency of the retention of artificial dentures. George H. Wilson recognized this important fact when he wrote, "The soft tissue is the factor that creates the variableness in impression taking."[8]

Within the circle described by the musculature of the upper and lower jaws, there are many structures of particular interest to the student of prosthesis. These structures, from the surface of the oral cavity, are: the oral mucous membrane, fibrous connective tissue, adipose or fat tissue, mucous glands, blood vessels, nerves and bone.

### ORAL MUCOUS MEMBRANE

The oral mucous membrane consists of two distinct parts, the epithelium and fibrous connective tissue.

The epithelium (*E*) which lines the oral cavity is of the stratified squamous type. In the deeper layers, the cells are longer and resemble the columnar form. Supporting the epithelium is a fibrous connective tissue that varies in character and thickness in the different regions of the mouth, and in different persons. It is known as the lamina propria (*LP*)[9] or

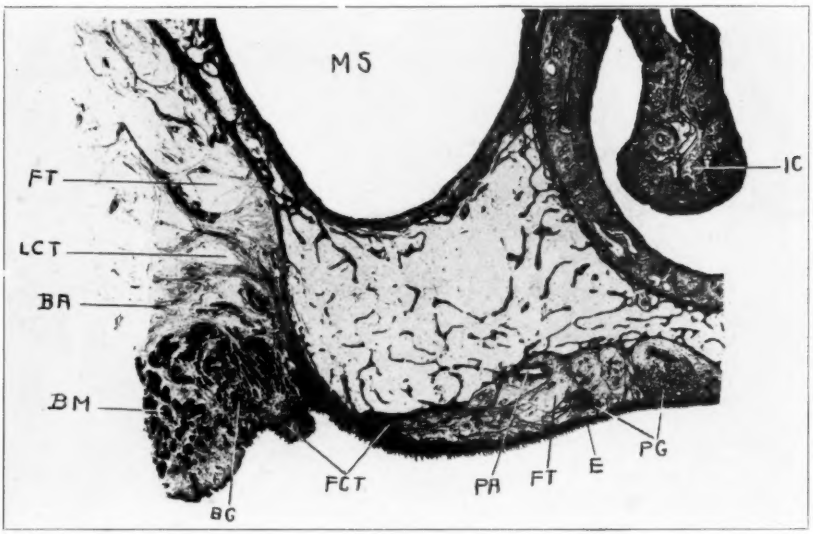


Fig. 4.—Frontal section, in the molar region, from the upper jaw of man, aged 62. *FT,* fat tissue; *LCT,* loose connective tissue; *BM,* buccinator muscle; *PG,* palatine glands; *FCT,* fibrous connective tissue; *PA,* palatine artery; *E,* epithelium; *MS,* maxillary sinus; *BA,* buccinator artery; *BG,* buccal glands; *IC,* inferior concha.

8. Wilson, G. H., Manual of Dental Prosthetics, Ed. 4, Philadelphia: Lea and Febiger, 1920; p. 63.

9. Maximow, A. A., and Bloom, William: Text-Book of Histology, Philadelphia: W. B. Saunders Company, 1930; pp. 46-483.

tunica propria.[10] Its fibers run parallel to the surface of the epithelium. In the lips and cheeks, it is of a looser character than that found in the vault of the maxilla and in the region of the residual alveolar ridges, where it is usually thick and very dense.

### DENSE FIBROUS CONNECTIVE TISSUE

The fibrous connective tissue in the vault of the palate of the maxilla varies in character and thickness. It is usually most dense in the anterior portion as far posteriorly as the first molar teeth. Here, it appears thinner and more elastic.

The density of this supporting tissue in the anterior portion of the vault seems to characterize the state of development of the palatine rugae. This tendency appears as an individual variation rather than one that is affected by age. A specimen illustrating the development of this fibrous tissue has been shown in a previous report.[11] This section was prepared from a man, aged 45. The rugae are completely lacking and the fibrous connective tissue supporting the epithelium is moderately developed, while a specimen prepared in the same field from a woman, aged 58,[12] shows highly developed rugae

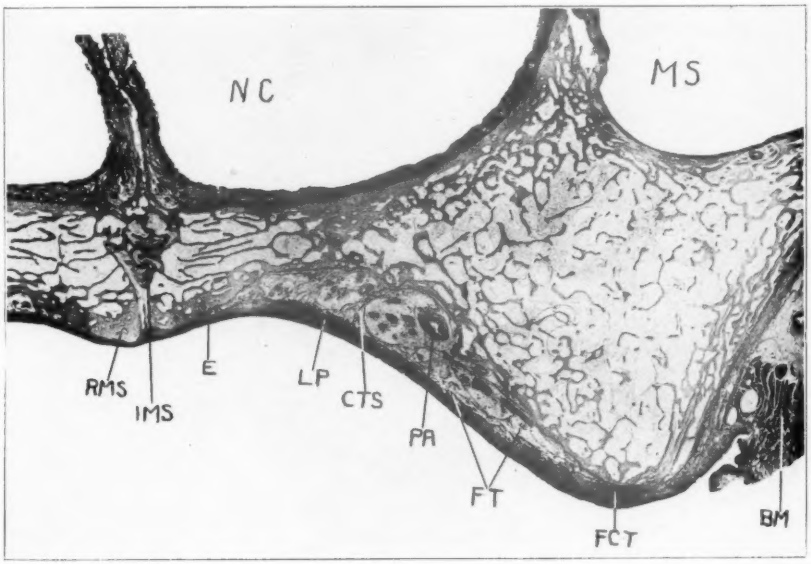


**Fig. 5.—Left half of the upper jaw in the bicuspid region from a woman, aged 51. *IMS,* intermaxillary suture; *NC,* nasal cavity; *BM* buccinator muscle; *FCT,* fibrous connective tissue; *FT,* fat tissue; *PA,* palatine artery; *E,* epithelium; *MS,* maxillary sinus; *RMS,* ridge of maxillary suture; *LP,* lamina propria; *CTS,* connective tissue septums.**

10. Noyes, F. B.: Text-Book of Dental Histology and Embryology, Ed. 4, Philadelphia: Lea and Febiger, 1929; p. 290.

11. Pendleton, E. C.: The Anatomy of Maxilla from Viewpoint of Full Denture Prosthesis, J. A. D. A., 19:543-572 (April) 1932. (Figure 4.)

12. Footnote 11. (Figure 21.)

and a considerable quantity of fibrous connective tissue supporting them.

Dense fibrous connective tissue is found covering the crest of the residual alveolar ridges of both the upper and the lower jaws except at their posterior extremities, which are marked by the tuberosity of the maxilla and the retromolar region of the mandible. At the extreme borders of on the buccal and labial surfaces of the residual alveolar ridges of both jaws. Its character in this region is less dense than at the crest of the alveolar ridge. (Fig. 3.) A median zone of fibrous connective tissue extends, as a fibrous band, from the crest of the residual alveolar ridge near the incisive papilla, along the hard and soft palate to the uvula.

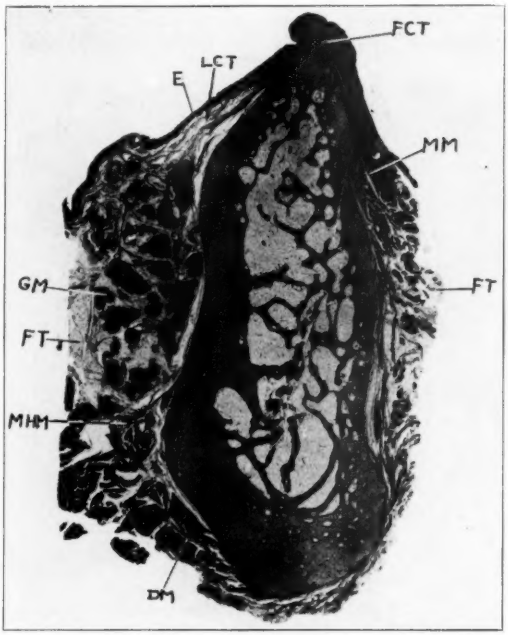


Fig. 6.—Buccolingual section through cuspid region of lower jaw of man, aged 80. *FT,* fat tissue; *MM,* mentalis muscles; *FCT,* fibrous connective tissues; *LCT,* loose connective tissue; *E,* epithelium; *GM,* glossomandibular glands; *MHM,* mylohyoid muscle; *DM,* anterior belly of digastric muscle.

these anatomic landmarks, there is a considerable amount of loose connective tissue (*LCT*). (Figs. 1 and 13.) This variation in tissue distribution is very important from the standpoint of denture retention.

The fibrous connective tissue extends

LOOSE FIBROUS CONNECTIVE TISSUE

Loose connective tissue (*LCT*) is found in the vault of the palate of the maxilla and at the outer borders of the alveolar ridges wherever there is a physiologic need for elasticity and mobility of the structures. It is seen above and

below the muscles that form the lips and cheek, and in the velum palati, where these elastic fibers aid the free movement of the associated parts. (Fig. 4.) In the mandible, this tissue is found about the structures in the floor of the mouth and supporting the labial and buccal tissues. Strands of connective tissue fibers, extending in a vertical plane from the periosteum to the lamina propria, subdivide by the ridge of the intermaxillary suture. It occupies an area extending from the incisive foramen to a frontal plane in the region of the first molar tooth. It is present in the entire space between the periosteum and the mucosa. In the region posterior to the first molar tooth, the adipose tissue is progressively less abundant and mucous glands occupy its place in the lining of the soft palate.

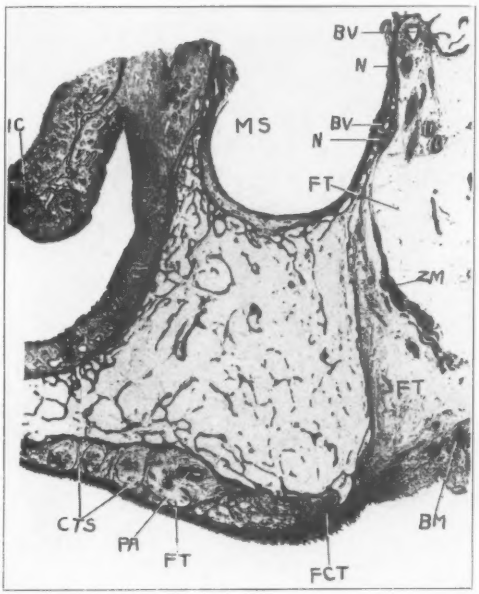


Fig. 7.—Frontal section, in bicuspid region from upper jaw of man, aged 62. *MS*, maxillary sinus; *BV*, blood vessels; *N*, infraorbital nerves; *FT*, fat tissue; *BM*, buccinator muscles; *FCT*, fibrous connective tissue; *PA*, palatine artery; *CTS*, connective tissue septums; *ZM*, zygomaticus major muscle; *IC*, inferior concha.

and support the fat tissue in the vault of the palate. (Figs. 5 and 7.)

### ADIPOSE TISSUE

Adipose or fat tissue (*FT*) is found in the hard palate lying in two symmetrical fields that are bounded laterally by the residual alveolar ridge and medially (Fig. 3.) In the lower jaw, a considerable amount of adipose tissue may be found in the areolar tissues adjacent to the musculature and glandular structures, particularly in the floor of the mouth. (Fig. 6.)

Adipose tissue is abundant throughout the soft tissues of both jaws. It is con-

sistently found in definite zones, but its amount varies greatly. This tissue is constant in its position between the muscle fibers, and around the larger vessels and nerves, especially in the vault of the palate and between the muscles of the lips and cheeks. (Fig. 7.) In the lower jaw, adipose tissue may be seen in a corresponding location on the labiobuccal surfaces below the muscle fibers. In the floor of the mouth, varying amounts of fat tissue are found about the muscle fibers and the glands at the lingual surface of the residual alveolar ridge. (Fig. 8.)

Sagittal sections prepared from the upper jaw show a layer of fat tissue supporting the mucosa at a position linguad from the incisive foramen and extending posteriorly to the anterior portion of the ridge of the intermaxillary suture. At its posterior border, another area of fat tissue lies between the palatine bones and the mucosa of the soft palate. Between the muscles and glands that go to make up the movable velum, an abundance of adipose tissue forms their support. The area of adipose tissue increases especially at the extreme anterior and posterior

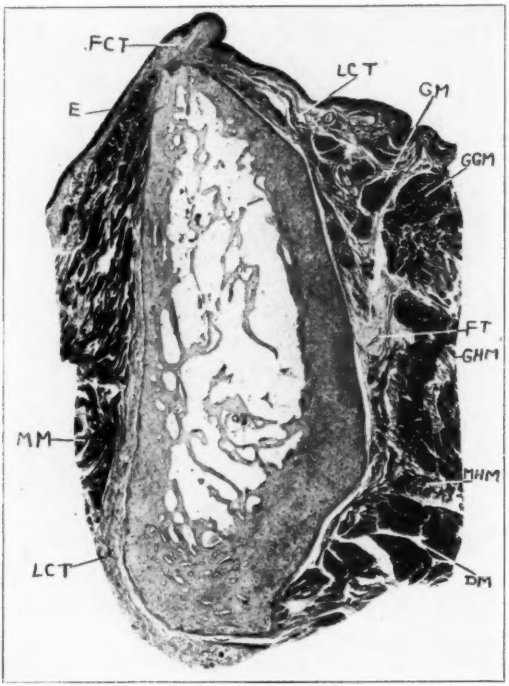


Fig. 8.—Labiolingual section through lateral incisor region of lower jaw from man, aged 80. *FCT,* fibrous connective tissue; *LCT,* loose connective tissue; *GM,* glossomandibular glands; *GGM,* genioglossus muscle; *FT,* fat tissue; *GHM,* geniohyoid muscle; *MHM,* mylohyoid muscle; *DM,* anterior belly of digastric muscle; *MM,* mentalis muscle; *E,* epithelium.

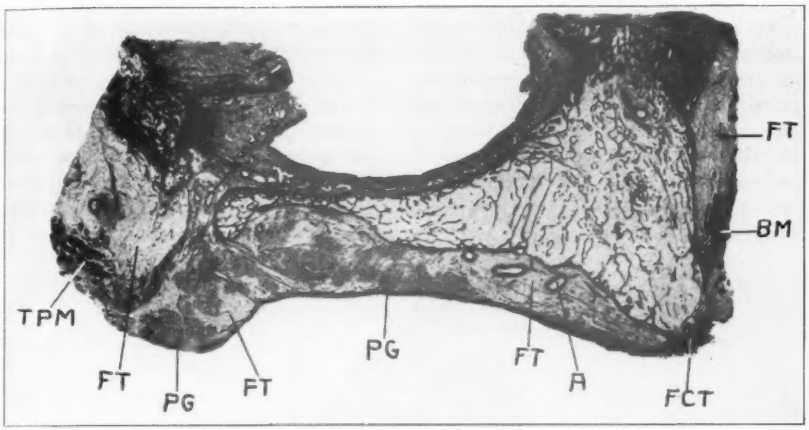


Fig. 9.—Sagittal section through lateral incisor region of edentulous ridge of upper jaw of man, aged 62. *FT,* fat tissue; *BM,* buccinator muscle; *FCT,* fibrous connective tissue of ridge; *A,* palatine artery; *PG,* palatine glands; *TPM,* tensor palati muscle.

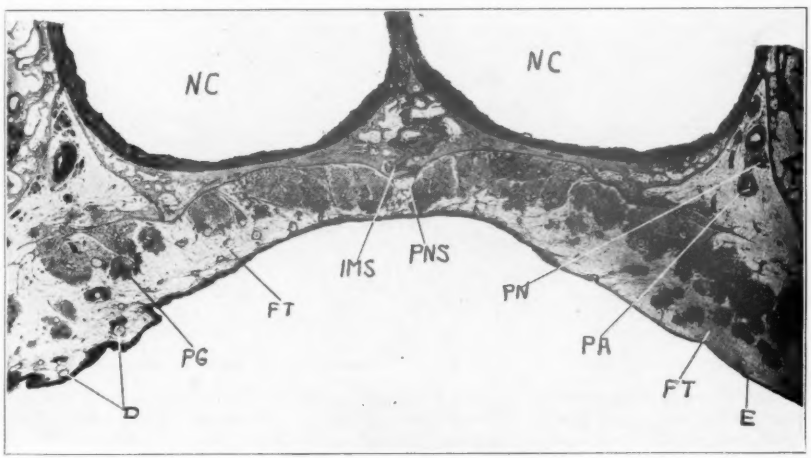


Fig. 10.—Frontal section through region of posterior nasal spine of upper jaw of woman, aged 51 (postdam area). *PNS,* posterior nasal spine; *IMS,* intermaxillary suture; *FT,* fat tissue; *PG,* palatine glands; *D,* ducts; *PN,* palatine nerves; *E,* oral epithelium; *NC,* nasal cavity; *PN,* palatine artery.

portions of the vault of the palate as sections that were remote from the median line are examined. (Fig. 9.)

Sections prepared in a frontal plane display an area of fat tissue of characteristic development in the bicuspid region between the residual alveolar ridge and the ridge of the intermaxillary suture.

(Fig. 10.) In some specimens, a considerable quantity of fat may be seen in sections prepared in the region of the posterior nasal spine. In sections prepared in a frontal plane through the area of the greater palatine foramen, fat tissue surrounds the blood vessels and nerves. It is also found between the oral mucosa and the palatine glands. (Fig. 3.)

somandibular and sublingual glands are the more important to the prosthetist. No doubt, our previous studies of the anatomy of the jaws have not presented the vivid picture of these structures that is shown in the histologic sections. In the upper jaw, the palatine glands are most numerous near the median line in the molar region and at the posterior border of the hard palate as a part of the

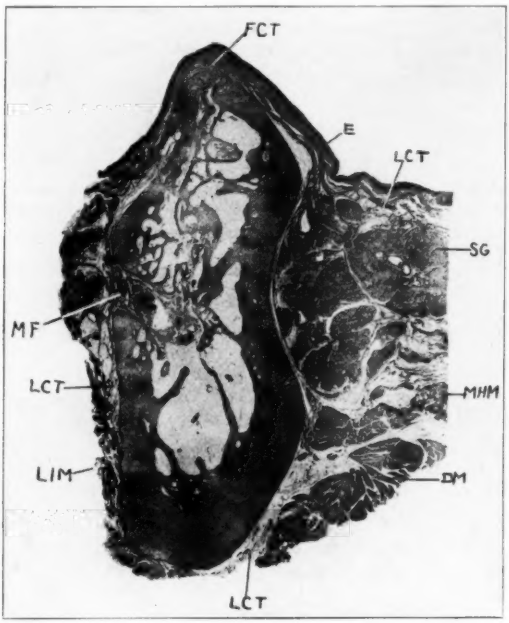


Fig. 11.—Buccolingual section through lower jaw, in region of mental foramen of man, aged 80. *MHM,* mylohyoid muscle; *SG,* sublingual gland; *LCT,* loose connective tissue; *E,* oral epithelium; *FCT,* fibrous connective tissue; *MF,* mental foramen; *LIM,* labii inferioris muscle; *DM,* anterior belly of digastric muscle.

GLANDS OF THE ORAL CAVITY

The glands (*G*) of the oral cavity are classified by Maximow and Bloom according to their location.[9] Those pertinent to this study are the labial, buccal, glossomandibular, sublingual and palatine glands. Of these, the palatine, glospalatine velum. They usually occupy an area on either side of the median line of the hard palate bounded by the residual alveolar ridges as far anteriorly as the first molar tooth. (Figs. 4-9.) In the submucosa of the soft palate, many large glands are found beneath the muscula-

ture. Individual variations are observed in the development of the palatine glands. Their location seems uniformly constant.

Many small ducts from the palatine glands open into the oral cavity through the submucosa and epithelium, as seen in Figure 10.

The glossomandibular glands appear in the anterior part of the arch beneath the floor of the mouth on the lingual surface of the mandible. They are separated from the mucosa by loose areolar tissue composed of connective tissue and some intervening fat. These glands are numerous and usually quite small. The glands near the mucosa are larger than those sheltered by the irregular surface of the body of the bone. The glands are separated into clusters by fat and bands of fibrous tissue. (Fig. 6.)

The sublingual glands are large and, like the glossomandibular, the larger glands are near the floor of the mouth. There is a considerable amount of areolar tissue between the mucosa and the sublingual glands. A larger band of areolar tissue separates the sublingual glands from the musculature. Embedded in this areolar tissue are blood vessels and nerves. (Fig. 11.)

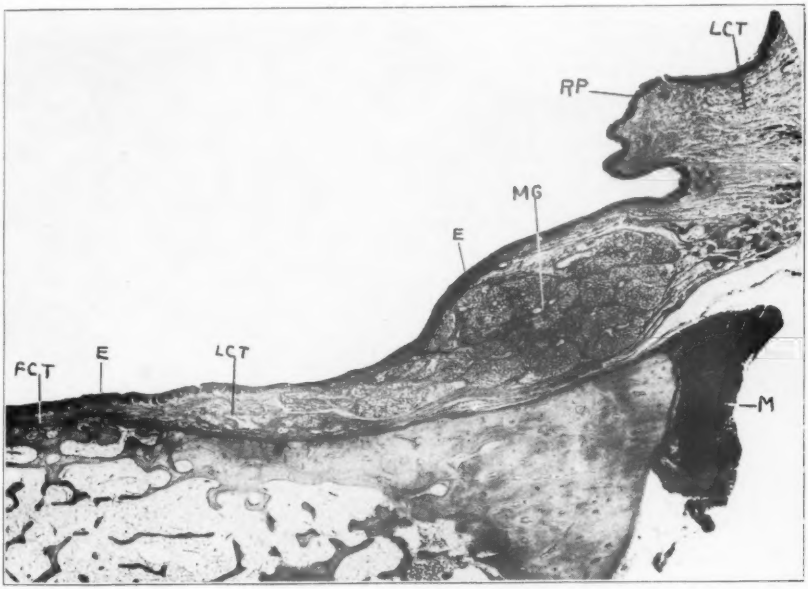


Fig. 12.—Sagittal section through retromolar region of lower jaw of woman, aged 51. *E*, epithelium; *FCT*, dense fibrous connective tissue; *LCT*, loose connective tissue; *MG*, mucous gland (retromolar gland); *RP*, retromolar papilla; *BM*, buccinator muscle.

In the upper jaw, the labial glands are found at the height of the vestibulum beneath the mucous lining of the lip. They lie just beneath the musculature and are separated from the surrounding structures by areolar tissue. The buccal glands are small and are seen in the

areolar tissues between the mucous lining of the cheeks and the fibers of the buccinator muscle. (Fig. 10.)

It might readily be assumed from the examination of these sections that the size and number of glands, like all other structures, display variations characteristic of the individual from whom the specimen was obtained. The buccal glands are largest where the soft tissues are most abundant.

thesis. The retromolar glands are also shown in Figure 1, which was prepared in a frontal plane from a corresponding region on the opposite side of the same specimen. The retromolar field is thus shown in two dimensions. On the lingual surface of the mandible, these glands are separated from the oral mucosa and the musculature by deep layers of areolar tissues. Clinically, the structures in the retromolar region are very elastic and

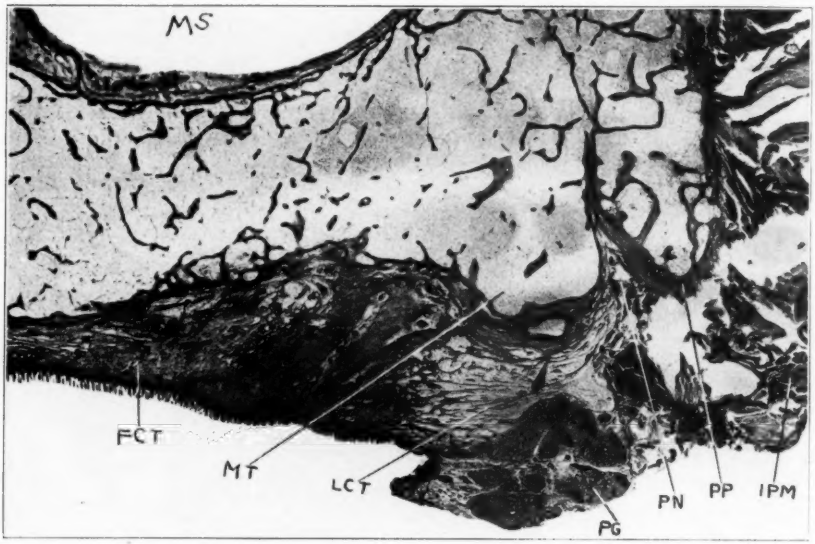


Fig. 13.—Sagittal section along residual alveolar ridge of upper jaw at tuberosity region from man, aged 62. *FCT,* fibrous connective tissue; *MT,* maxillary tuberosity; *LCT,* loose connective tissue; *PG,* palatine glands; *PN,* pterygoid notch; *PP,* pyramidal process of palatine bone; *IPM,* internal pterygoid muscle; *MS,* maxillary sinus.

Mucous glands have also been found in the retromolar area of the mandible. (Fig. 12.) They occupy the field between the oral mucosa and the upper surface of the mandible anterior to an eminence of the mucosa, which, for convenience of description, is here referred to as the retromolar papilla. It has importance as an anatomic landmark in denture prosthesis. The retromolar glands are also shown in Figure 1, which was prepared in a frontal plane from a corresponding region on the opposite side of the same specimen. The retromolar field is thus shown in two dimensions. On the lingual surface of the mandible, these glands are separated from the oral mucosa and the musculature by deep layers of areolar tissues. Clinically, the structures in the retromolar region are very elastic and they therefore present an "area of variability" in denture prosthesis.

Mucous glands which are probably a division of the palatine glands may be found in sagittal sections of the maxillary tuberosity region. (Fig. 13.) This field includes the lingual surface of the maxillary tuberosity and a portion of the pyramidal process of the palatine bone. It

shows glandular structures near the mucosa of the soft palate which are separated from the tuberosity and the mucosa by a quantity of areolar tissue. The elasticity of the structures in this region presents an area of particular interest to the prosthetist.

### MUSCLES OF THE JAWS

The muscles are attached to both the maxilla and the mandible. At the buccal and labial surfaces, they are attached directly to the bone; while, at the posterior border of the maxilla, the muscles of the soft palate have their primary attachment by an aponeurosis, some of their fibers being fixed directly to the bone.

Sections prepared in a frontal plane through the lower jaw show the muscles of the lips and cheeks attached to the labial and buccal surfaces of the mandible in an area extending from near the crest of the residual alveolar ridge to the lower border of the body of the bone. (Fig. 8.)

The muscles that form the floor of the mouth are attached to the lingual surface of the mandible. In the anterior portion near the median line, the genioglossus and the geniohyoid muscles are attached to the genial tubercles. (Fig. 14.)

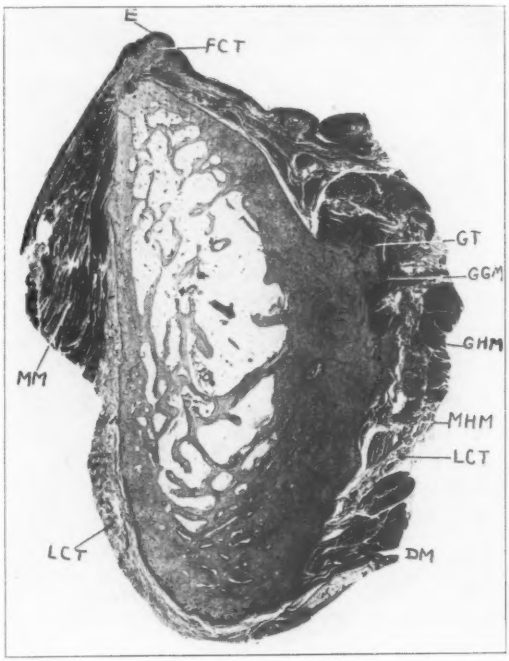


Fig. 14.—Labiolingual section in central incisor region through lower jaw of man, aged 80. *DM,* digastric muscle; *LCT,* loose connective tissue; *MM,* mentalis muscle; *GT,* genial tubercles; *GGM,* genioglossus muscle; *GHM,* geniohyoid muscle; *FCT,* fibrous connective tissue; *MHM,* mylohyoid muscle.

In the sections prepared in the cuspid, bicuspid and molar regions, the lingual muscle attachments are found at the lower one third of the body of the mandible.

In recent dissections made by William N. Holmes in collaboration on this study, the mylohyoid muscle was observed as a thin fan-shaped structure with its attachment at the border of the mylohyoid ridge. This difference in the macroscopic and the microscopic findings may be an individual variation. This variation has presented an important problem that will be pursued farther, as a definite knowledge of the position of the lingual muscle attachments is a factor of fundamental significance in determining the design of the prosthetic appliance.

Fig. 15.—Frontal section through deciduous second molar region in infant, aged 6 weeks (specimen from the collection of William H. G. Logan). *UJ*, upper jaw; *FT*, fat tissue; *BM*, buccinator muscle; *V*, vestibulum; *MT*, second deciduous molar tooth; *M*, mandible; *PM*, platysma muscle; *DM*, anterior belly of digastric muscle; *MHM*, mylohyoid muscle; *MR*, mylohyoid ridge; *SG*, sublingual gland; *T*, tongue; *PG*, palatine glands; *OM*, oral mucosa; *LCT*, loose connective tissue.

### BLOOD VESSELS AND NERVES

The tissues of both the upper and the lower jaw are well supplied with blood vessels and nerves. The larger vessels, as

well as the nerves of the upper jaw, are sheltered in a groove of the bone well protected by adipose tissue. The nerves are grouped into bundles many of which consist of twenty or more smaller strands. (Figs. 3-5.)

OSSEOUS STRUCTURES OF THE JAWS

A study of a section prepared in the region of the second deciduous molar tooth from a child 6 weeks old (Fig. 15) shows a portion of the upper jaw, the palatine structures, the buccal fold in the upper and the lower jaws, the tongue and the structures that form the floor of the mouth. It is significant that the location, arrangement and relation of the structures are uniformly constant. While their character may present changes due to biologic, pathologic or mechanical conditions, the picture of the parts is readily recognized regardless of the age of the individual or the form of the structures.

The structural framework of the maxillae and palatine bones is dense. Its inner and inferior surfaces show the most compact form, while the outer and superior surfaces are of a lighter nature. This characteristic is prevalent throughout the maxilla and the mandible except in sections prepared from the posterior region of the mandible where the external oblique line shows a dense development of the outer layer of bone from the position of the first molar tooth posteriorly to the ascending ramus.

The residual alveolar processes of the edentulous upper and lower jaws are the most massive bony structures except in those cases displaying protracted resorption. The residual alveolar process is a structure which, on account of its form and position, vitally affects the retention of complete dentures. In this study, greater attention has been given to the soft tissues since they are the more variable factor in retention.

The bony ridge of the edentulous alveolar process varies greatly, the principal variations being evidenced in the extent of their development and the degree of their resorption. The form and size of the ridge displays considerable contrast in the different regions of the arch. It is composed of a dense palatine plate of bone and a thinner buccal plate supported by a base of compact nature. The central portion or body of the process is of a cancellous type. Within the body, the reticular form of the trabeculae bridges the structure and the fatty marrow supplies a supporting element. Throughout the alveolar processes, there are numerous Volkmann canals.[9] Many small depressions and elevations may be found on the external surfaces of the residual alveolar ridge which shelter the blood vessels and nerves and furnish a favorable attachment for the muscles and connective tissues.

Sections of the residual alveolar ridge prepared in a frontal plane display a strikingly similar picture to those in a sagittal plane. There appears much variation in the density of the cancellous structures in specimens prepared from different persons. It is seen that, in the specimens from those in middle life, the framework is compact; while in those of more advanced age, the trabeculae are thin and the marrow spaces are greatly increased in size. This characteristic exists also in the palatine processes where the least atrophic change occurs.

Sections prepared in a frontal plane usually show the horizontal plates of the maxillae and the palatine bones united in the median line by an irregular suture that is well defined. In other specimens, the suture is nearly obliterated and the processes appear to be fused. In sagittal

sections, the maxillae and the palatine bones are united by a transverse suture.

The union of the maxillae is marked by an irregular development of bone that sometimes assumes the proportions of an osseous tumor. This prominence, usually found extending from a frontal plane in the cuspid area to the second molar region, is termed the ridge of the intermaxillary suture, because it appears as a growth of bone reinforcing the articulation of the palatine processes of the maxillae. This area presents many hazards to the prosthetist, not alone on account of its character, form and position, but also because of its affect on the materials used in impression taking, as it influences their action on the soft tissues in the vault of the palate.

The clinical application of the knowledge of the minute structures of the edentulous jaws can be made with complete assurance. The different structures described are common to and characteristic of the edentulous jaws. They are easily distinguishable when once the student has become familiar with their position, quality and clinical characteristics.

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# REPLANTATION OF BICUSPID

By F. L. ROUNTREE, D.D.S., Cedartown, Ga.

HEREWITH are shown a roentgenogram (Fig. 1) of a lower second bicuspid that was extracted in 1920. While the patient was still in the chair, I ground away about one-sixteenth inch of the root, up to the root filling. The root, which was not filled to the end, was giving trouble. I held the tooth steady with amalgam placed in the bicuspid and molar, until it was able to support itself, a matter of a few months. Figure 2 shows how Nature filled in the missing space with bone. This tooth has lasted thirteen years, with perfect function. I also replanted an upper cuspid that lasted seven years.

Fig. 1.—Replanted lower second bicuspid.

Fig. 2.—Replanted lower second bicuspid.

# The Journal of the American Dental Association

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C. N. JOHNSON, Editor

NEWTON G. THOMAS, Associate Editor

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# *Editorials*

## ENCOURAGING COOPERATION BETWEEN THE NATIONAL ASSOCIATION OF BROADCASTERS AND ORGANIZED DENTISTRY

The immense influence exerted by the radio on the citizens of any country is a matter calling for the closest consideration on the part of thinking persons everywhere, and this is particularly true of all matters pertaining to health. Unless the closest supervision is had over the material that is broadcast, it is a very easy matter to introduce propaganda of a pernicious nature fostered by men with motives of personal profit and aggrandizement.

It is a fortunate thing that the control of radio has for the most part been in the hands of men who have a keen sense of responsibility, and who lend their influence for the better things of life. As proof of this, we have only to refer to the attitude of the officials of the National Association of Broadcasters in a recent conference with the officials of the American Dental Association at Washington on this important matter.

In the NAB report for Jan. 6, 1934, we find the following notation:

> Cooperation of the NAB and the Federal Radio Commission in its effort to prevent broadcasting by individual dentists is being sought by the American Dental Association.
>
> The subject was discussed at a recent conference attended by Dr. A. C. Wherry, president of the Association; Dr. C. T. Messner of the U. S. Public Health Service; Dr. C. Willard Camalier, trustee of the Association; Commissioner Harold A. Lafount; James W. Baldwin, NAB; and Philip G. Loucks, managing director of NAB.
>
> Dr. Wherry pointed out that his Association had adopted a resolution condemning broadcasting by individual dentists and in a letter to the Federal Radio Commission had referred to this practice as "selfish, unprofessional and commercial." He agreed that the enforcement of ethics within the dental profession was a matter for his Association and state licensing bodies, but asked that the NAB and the Commission cooperate with the dentists of the country in protecting the public against the unethical dentist. Newspapers are also being asked to cooperate, he said.
>
> While the resolution adopted by the Dental Association at its last annual convention was rather broad in scope it was aimed primarily at the "advertising dentists." "This is a problem," Dr. Wherry has pointed out in his letter to the Commission, "which, if not curtailed in its infancy, may develop into a serious situation, as it relates to the health of the people through the dental profession."
>
> The Dental Association, it was pointed out, is not urging legislation or regulations on the subject but has chosen instead to work cooperatively with the broadcasters.

The hearty cooperation of the radio officials in this matter is most encouraging, and our Association is under the deepest obligation to them for their courtesy and consideration. Of particular service to us on this occasion was the managing director of NAB, Mr. Philip G. Loucks. Mr. Loucks exhibited a spirit of cordial encouragement, and demonstrated at once that he had a most intelligent grasp of the essential needs of organized dentistry in its relation to public welfare. Evidently, the NAB officials are keenly alert to the wiles of the professional charlatan or quack in his attempt to exploit the people, and are determined to safeguard the interests of the citizens in every way in their power.

Any agency that touches the welfare of society as vitally and as intimately as does radio needs the directing hand of wise and discriminating officials, and it is a source of great satisfaction to note the present attitude of so influential a body of men as the NAB. The radio interests may be assured that the American Dental Association appreciates to the fullest extent the courtesy extended at this

conference, and pledges its cooperation in every worthy endeavor to safeguard the best interests of the profession and the people.

## WOULD YOU TAKE THEM OUT?

Ever since the raid on pulpless teeth was started, it has been a nice question at times to decide which teeth shall come out and which not, and to this day there are times when it is a difficult matter to decide with certainty. No man is wise enough to tell in all instances just what should be done, and there are some cases, even with all the observation and experience at our command, in which the decision remains an open question.

But this one thing we do know, and it should be drummed into the ear of every self-respecting dentist, that the widespread tendency on the part of certain medical men to order the extraction of every pulpless tooth should be resisted to the last ditch. Not only this, but, in too many cases, physicians are presuming, on roentgen-ray evidence alone, to order the extraction of teeth with pulps alive and healthy, and sometimes without any evidence at all. Any recession of the alveolar process between teeth as shown by roentgenograms is heralded as "infection," and the teeth are ordered out. Irreparable damage has been done in this way; and, in spite of the utmost endeavor on the part of dentists to point out these facts, there are certain physicians who do not scruple to order the extraction of normal and useful teeth without consultation and in the most bizarre manner.

The assumption on the part of these men that they are better informed on the subject of the teeth than are dentists is accountable for much miscarriage of judgment and much injury, and a halt should be called on it in no uncertain terms. This is an old question and it has been agitated pro and con for years. The better informed and more conservative men of the medical profession have long since been gracious enough to pass this subject up to the dentist and ask for consultation, and when this is done, the best interests of the patients are usually safeguarded; but there is another type of man who superciliously ignores the opinion of the dentist, and presumes

to pit his judgment against the consensus of opinion of men who have spent their lives in the study of the teeth, and who, if there is any intelligence in them at all, know more about the subject than it is possible for the physician to know with his necessarily limited experience.

To the great benefit of the people, there is an ever-growing disposition on the part of both callings to seek closer cooperation and more frequent consultation, and when this becomes general, the people will be better served. Let this fact sink in, that there are certain cases in which it is beyond the ken of mortal man—physician or dentist—to state definitely whether a given tooth is doing any damage. For this reason, there are countless numbers of harmless teeth that have been extracted in the past on suspicion that they might be causing injury, and, up to a certain point, there may be justification for the loss of some useful teeth under such circumstances. We do not wish to place in jeopardy the welfare of any patient by a blind persistence in our point of view, but we have a right to object when a physician takes it on himself to pass judgment on the teeth and order their extraction without the slightest justification, and with no evidence for his decision except his own imagination. We court the closest cooperation of the medical profession in our efforts to arrive at a just evaluation of the teeth, but we believe that as self-respecting professional men we should no longer accept the situation complacently, when dictation is substituted for cooperation.

Let us ask some of our medical friends who today are so insistent on the extraction of pulpless teeth among their patients, but who retain in their own mouths a number of pulpless teeth, as is frequently the case—let us ask them the pointed question, would you take out your own pulpless teeth? We have heard of very few of them who have the courage of their convictions in sufficient degree to sacrifice their own teeth; and when this is the case, is it not logical to demand that the same consideration and conservatism be shown the patient that they reserve for themselves? Consistency is a jewel in this as in every other relation of life, and all we ask is that certain of our radical friends show some consistency. Would *you* have your own teeth taken out?

## AN OPEN LETTER TO MY FRIEND THE FULL DENTURE SPECIALIST

*My dear Doctor:*

I envy you and I am sorry for you. At once I hear you say that this is a contradiction in terms, but it is not.

I envy you because of your uncanny ability to transform the human countenance from a spectacle of decrepit old age with its hideous gaping void, to the lines of youth and the contour of symmetry and grace. Yours is the wizardry of reclamation. Without you, all is lost.

The growing child suffering the blight of deformity is vouchsafed the sure blessing of regeneration through orthodontia. The forces of nature blend their beneficence with the subtle art of the magician and, lo and behold, a new being is born!

In your case the forces of nature are all against you. You are compelled to reach out the helping hand when the adventure seems well-nigh hopeless, when—lacking your ministrations—there is no prospect of comfort or joy in life. Instead of the aid that is given the orthodontist by natural development, you are constantly combated by the forces of inevitable disintegration. You are obliged to cope with declining days and degenerating tissues. You are asked to build up where nature has torn down, to reconstruct where nature has taken away.

You are confronted with the limitations of flesh and blood, and are blandly called on to perform the impossible. This is why I say that I am sorry for you. But no, I am not sorry—I revise my decision. No one is entitled to sympathy merely because he has a difficult task to perform. Let him rather glory in the fact that he has been accorded the precious privilege of overcoming obstacles.

People are unreasonable with you at times, and mayhap impetuous. Never mind, the greater victory is yours when you finally conquer, as you will. And there is this: You have not only yourself to please, and you have not only your patient: you have all of those who are the patient's friends. Each has his crotchets, and each has his barbed shaft on which to impale your peace of mind. But peace

of mind is gained only through tribulation and triumph. Be thankful.

To you is assigned the task of making human life more livable, more bearable. What would be the plight of civilized humanity today without your service? The pitiable helplessness of your patient makes for you the strongest appeal, an appeal to your magnanimity, to your imagination, to your ingenuity and to your devotion to duty. Yours is an obligation of humanity itself, far beyond the incentive of material reward, greater even than the glory and glamour of the soldier on the field of battle.

You suffer disappointment, but out of disappointment comes the benediction of patience, and through patience there is ultimate victory. To you is granted the sublime assignment of rescuing from human kind the pallid fear and despair of nature's senile blight; and blending with the beneficence of the artisan, the comely grace and beauty of the artist.

You are pledged to work a miracle of color and of form, and to round the whole in a consummation of function and facile art. You not only restore: you really create; you not only blend, but you design.

Blessed be the man who has found his task, who in his daily round encounters the grim demand of constant strain and stress. Out of stress comes fruition, and out of fruition comes content.

I congratulate you and I acclaim you as one of the great moving constructive forces of our modern era. You are a benefactor of your race, a blessing to stricken humanity. In your own ranks, you do not always agree, but out of disagreement comes knowledge and out of knowledge comes power.

I admire your virility and your constant growth, your inventive skill and your basic quest for truth. Your trials are as nothing compared with your achievements, and in the sum total of all that men most crave of life, yours is the assurance of having found your niche, and played your part.

I give you my fraternal regard and my best blessing, and all I ask is the privilege of being called

Your friend,
C. N. J.

## EXTRACT FROM THE ADMINISTRATIVE BY-LAWS

The following extract from the Administrative By-Laws of the Association, Chapter I, Section 3, is self-explanatory:

Sixty (60) days after January 1, the General Secretary shall drop from the membership roll the names of all whose dues for the current year shall not have been received.

It will therefore be necessary to discontinue mailing THE JOURNAL to those members who are affected by the foregoing regulation.

This is the last issue that you will receive unless you have paid your 1934 dues.

# *Obituaries*

## JOHN ELLSWORTH BANKS

(1865-1934)

John Ellsworth Banks died at his home in Yakima, Wash., Jan. 6, 1934. He was born in Mansfield, Ohio, in 1865. His early dental training was received under the tutelage and in the office of Dr. Stone, of Norton, Kan. Coming west, he located in Port Townsend, Wash., where he studied under Dr. Stanley of that city. Taking the state board examinations after years of study, he received the highest grades given at that meeting. He was married the same year to Lou A. Graves, of Port Angeles, Wash.

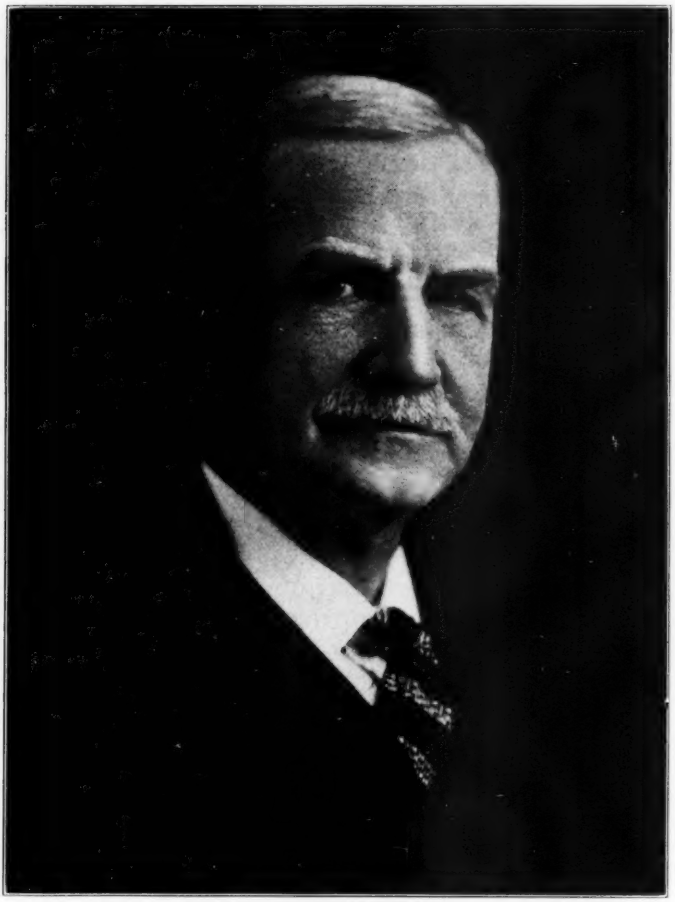
Moving to Ellensburg, Washington, he became an associate of Dr. B. S. Scott. After practicing there for three years, he moved to Yakima, where he continued to practice until his death.

Dr. Banks was an enthusiastic member of the Yakima Valley Dental Association from the time of its organization in 1923, but his affiliation with organized dentistry dates back to 1895. To him belonged the honor of being the first honorary life member of the Washington State Dental Association.

He was held in high esteem by all who knew him, both in the profession and out. His honest, outspoken manner was admired by all his acquaintances. His opinions and advice were always welcomed in society meetings, for they were unbiased and came from knowledge gained in many years of experience.

His widow, two daughters, one brother, and five sisters survive him.

BERNARD A. SUTTON.



**JAMES PATTERSON HARPER, D.D.S.**
**(1863-1934)**

# JAMES PATTERSON HARPER, D.D.S.

(1863-1934)

James Patterson Harper was born in Fort Madison, Iowa, Nov. 9, 1863; died, February 13, at his home in St. Louis, Mo., after an extended illness.

Dr. Harper was a graduate of the Chicago College of Dental Surgery, class of 1895. He received his preliminary education in the schools of Indianapolis. On graduation from the dental college, he entered practice in St. Louis. He held the professorship of pathology and histology at Marion Sims Dental College from 1895 to 1916. In 1912, he was made dean of the St. Louis University School of Dentistry. He was made a member of the visiting staff of the St. Louis City Hospital in 1910, and became a member of the city board of education in 1911, acting as president in 1915-1916. He was a member of the national, state and city dental associations and the National Association of Dental Teachers. He served at one time as vice president of the American Dental Association.

Dr. Harper was a member of the City Club of St. Louis and a trustee of the Missouri Botanical Garden. He was commissioned as a first lieutenant, D. R. C., in the United States Army, in August, 1917, rising through the ranks of major and lieutenant colonel to a colonelcy in February, 1923.

Dr. Harper was married to Elizabeth Pike, of St. Louis, June 22, 1922. One son, James Durfee, was born to the union.

# COUNCIL ON DENTAL THERAPEUTICS

## ACCEPTED DENTAL REMEDIES

Beginning with the October, 1933, issue of THE JOURNAL, portions of the proposed book, Accepted Dental Remedies, appeared. In this issue of THE JOURNAL the last installment of the material for the book appears. There are also presented certain monographs, not in alphabetical order.

It is planned that this material will be collected in book form, and that the book will be available for distribution at a nominal cost.

The completed book will contain an index of the material already presented, the Rules of the Council and appendices containing information on symptoms and antidotes in poisoning of interest to dentists, definitions of pharmaceutic preparations, a chapter on weights and measures, a therapeutic index and a bibliographic index of reports of unaccepted products which have appeared in THE JOURNAL up to date of printing in book form.

Articles of similar composition or action have been grouped as far as possible, and each group is preceded by a general discussion. It is anticipated that after the book has been published, the general articles and the special articles will be revised annually.

The Council will appreciate constructive criticism which will aid in future revisions of the book, in order that the book may be of greatest usefulness to the dental profession.

SAMUEL M. GORDON, *Secretary.*

### SILVER PREPARATIONS

Silver compounds are used in dentistry to secure caustic, astringent, germicidal and antiseptic effects. These results are produced by the free silver ions. When caustic effects are desired, silver nitrate is preferred, because the organic compounds of silver are largely or completely lacking in caustic properties. As an astringent, silver nitrate is the compound of choice; but it must be used in weak solutions. The antiseptic action of silver nitrate is complicated by irritation, astringency and corrosion. These results may be desirable for the destruction of tissues or the stimulation of indolent wounds. When they are not necessary for such purposes, they are distinctly undesirable because they are painful. They may be avoided by the use of colloidal silver preparations, such as mild silver protein and strong silver protein, U.S.P.

Silver nitrate is used in the preparation of ammoniacal silver nitrate and for other therapeutic measures in the treatment of gangrenous dental pulp.

### SIMPLE SILVER SALTS

**SILVER CITRATE.**—Argenti citras, $Ag_3C_6H_5O_7$—The normal silver salt of citric acid.

**Properties:** Silver citrate forms an odorless, heavy powder, which is moderately sensitive to the light, from which it should be carefully protected. It is almost insoluble in water. Pure silver citrate, when heated to redness, leaves a residue of metallic silver weighing 63.16 per cent of the weight of the original salt.

**Actions and Uses:** Silver citrate is a nonirritating antiseptic. It is said to be useful in the treatment of wounds and ulcers and other diseases of the mucous membranes.

**Dosage:** It may be applied in substance to wounds. Solutions of from 1:4,000 to 1:10,000 are recommended for injection into the body cavities.

**Silver Citrate—Merck:** A brand of silver citrate, N.N.R. On heating it yields not less than 62 per cent of metallic silver.

Merck & Co., Rahway, N. J., distributor. No U.S. patent or trademark.

**SILVER LACTATE.**—Argenti lactas—$AgC_3H_5O_3 + H_2O$. The normal silver salt of lactic acid.

**Properties:** Silver lactate occurs in the form of crystalline needles, granular masses or crystal-

line powder. It dissolves in about 15 parts of water. Pure silver lactate when heated leaves a residue of metallic silver weighing 50.2 per cent. It is usually colored brownish and gives with water a brownish or reddish solution. The salt must be protected from the light.

**Actions and Uses:** Silver lactate is used as an active antiseptic. The 1:300 to 1:500 solution (aqueous) is said to be equal in disinfecting power to a 1:1,000 solution of mercuric chloride. It is irritating if applied in substance to wounds.

**Dosage:** From 1:100 to 1:2,000 solutions, or in substance.

**Silver Lactate—Merck:** A brand of silver lactate. On heating, it yields from 50 to 51.5 per cent of metallic silver.

Merck & Company, Inc., Rahway, N. J., manufacturer. No U.S. patent or trademark.

**SILVER NITRATE, U.S.P.**—Argenti nitras (Arg. nit.) $AgNO_3$.

**Properties:** Silver nitrate occurs in colorless, tabular, rhombic crystals, becoming gray or grayish black on exposure to light, in the presence of organic matter. It is odorless and has a bitter, caustic and strongly metallic taste. It is very soluble in water (1:0.4) and soluble in alcohol (1:30).

**Incompatibilities:** Silver nitrate is incompatible with soluble chlorides, bromides and iodides, with which it forms the corresponding insoluble salts of silver. It is also incompatible with soluble carbonates and hydroxides, which precipitate the oxide of silver; and with practically all organic drugs and reducing agents.

**Actions and Uses:** Silver nitrate is an antiseptic and germicide. A solution of 1:1,000 destroys many micro-organisms, and 1:10,000 prevents their growth. Weak solutions are astringent to mucous membranes and strong solutions are caustic when applied to mucous membranes, denuded surfaces and, in some cases, the normal skin. Its internal use continued for some time may be followed by the deposition of silver in the skin, producing the grayish discoloration know as argyria, which cannot be eliminated. Prolonged use should, therefore, be avoided.

Silver nitrate is applied as a mild caustic to wounds, ulcers and exuberant granulations. It is applied as an astringent and antiseptic in catarrhal infections of the mucous membranes. It is used in dentistry principally in the form of Howe's solution, ammoniacal silver nitrate (which see).

**Dosage:** As a caustic, silver nitrate is used in the form of fused silver nitrate, which should be moistened before use. To avoid blackening the fingers, it should be held with the forceps or in a suitable holder. It may be fused on a probe for application to parts that are difficult of access.

For application to mucous membranes, the following strengths of solution in water are most suitable:

Solutions containing from 2 to 10 per cent of silver nitrate may be applied to the pharynx. A 10 per cent solution is useful to cauterize small ulcerating surfaces on the buccal mucous membranes, such as occur in trench mouth. A 35 per cent solution is used by some in conjunction with Churchill's iodine solution in the treatment of trench mouth.

Solutions of silver nitrate should be made with distilled water, and the mucous membranes to which they are to be applied should receive a preliminary cleansing to remove mucus, pus, food, etc., which would interfere with the action of silver nitrate.

**FUSED SILVER NITRATE, U.S.P.**—Argenti nitras fusus (Arg. nit. fus.) (Lunar caustic, molded silver nitrate). A white, hard solid, generally in the form of pencils or cones. It contains a small amount of silver chloride which toughens the mass.

**Silver Nitrate Applicators:** (Silver nitrate, 75 per cent). Wooden sticks, 2 inches (5 cm.) and 6 inches (15 cm.) long, tipped with a mixture of silver nitrate, 75 per cent, and potassium nitrate, 25 per cent; each stick to be used only once.

Prepared by Arzol Chemical Company, Nyack, N. Y. No U.S. patent or trademark.

**AMMONIACAL SILVER NITRATE (HOWE).**—A solution containing approximately 30 per cent silver as silver diammino nitrate. Solution of silver diammino nitrate—approximately 57 per cent. $Ag(NH_3)_2NO_3$.

**Actions and Uses:** The silver salts form resistant precipitates with proteins which act to limit their penetration in vital teeth and immediately after pulp extirpation. The end-product of the application of silver nitrate to carious areas is probably a mixture of silver proteinates and reduced silver, owing to the action of light and other reducing agents. In order to hasten the reduction of the silver salt, the use of the complex silver ammonium compounds as the nitrate or the oxide ($Ag(NH_3)_2^+$) was introduced. The solution as prepared above contains

approximately 30 per cent of readily reducible silver. It is claimed that it is less toxic than silver nitrate *per se*. Its most important use in dental practice is based on its ready diffusibility into the dentin. The finely divided silver which is laid down by this process in carious dentin retards the progress of dental decay. When judiciously used, it is said to arrest completely the course of caries.

Properly used, ammoniacal silver nitrate is useful in root operations. The action depends not only on its bactericidal properties, but also on the fact that it combines with the toxic products of protein cleavage in such conditions as gangrene of the pulp.

The insolubility of the finely divided silver in the circulatory elements and the high tolerance of the tissues toward it has made it a useful agent in conditions mentioned above. The oligodynamic properties of silver inhibit the growth of bacteria. On account of its staining propensities, its use is generally confined to the posterior teeth.

When a thorough diffusion is desired, as in the treatment of toxic roots, the silver solution, without the use of a reducent, may be sealed in for a number of hours.

It is used for hypersensitiveness of the dentin, but because of its staining effect, its use is limited to posterior teeth.

**Ampoules Ammoniacal Silver Nitrate—P. N. Condit:** Solution of ammoniacal silver nitrate. Each ampule contains about 2 c.c. of ammoniacal silver nitrate prepared according to the directions of Percy R. Howe (*D. Cosmos,* 59:481, 1917). These ampules are accompanied by ampules containing 2 c.c. of a solution of formaldehyde, approximately 10 per cent.

**Actions and Uses:** (See preceding article on ammoniacal silver nitrate solution.)

**Dosage:** For use in prophylaxis against dental caries, a drop or two of the solution is applied to the carious area and reduced with eugenol or formaldehyde solution. For use in gangrenous pulp, a drop or two is applied locally and followed by the application of eugenol or formaldehyde solution 10 per cent. A special applicator is furnished by the manufacturer.

Prepared by P. N. Condit, Boston, Mass. No U.S. patent. Trademark No. 167462.

The following chemical standards have been developed in the Bureau of Chemistry.

Ammoniacal silver nitrate (Howe) is a clear, colorless solution prepared by the careful addition of strong ammonia water U.S.P. to a saturated solution of silver nitrate U.S.P. until all but the last trace of black precipitate is dissolved. The saturated silver nitrate solution should be prepared at ordinary temperatures (15 to 30 C.). It should contain not less than 28.0 per cent nor more than 32.0 per cent silver (Ag) and not less than 8.9 per cent nor more than 9.8 per cent ammonia ($NH_3$). The ratio %Ag:%$NH_3$ should not be less than 3.10 nor greater than 3.60. It should be marketed in all glass containers. The weight of 1 c.c. at 20 C. is between 1.45 and 1.55.

The solution is strongly alkaline to litmus. It yields an immediate black precipitate with 10 per cent formaldehyde solution (distinction from solution of silver and ammonium nitrate). A diluted solution (1:10) responds to the tests for silver and nitrate, U.S.P.X. Five cubic centimeters of a diluted solution (1:10), are treated with 2 c.c. diluted hydrochloric acid, filtered and made alkaline with 5 c.c. sodium hydroxide solution and boiled. The vapors turn red litmus blue (ammonia).

The solution is colorless, exhibiting not even the faintest blue (copper). To 1 c.c. of ammoniacal silver nitrate, add 3 c.c. of diluted hydrochloric acid, and filter. The clear solution when tested in a flame test with a platinum wire yields no more than the usual traces of alkali (sodium or potassium) (distinction from Tollen's reagent).

Accurately pipet 1 c.c. to a weighing bottle and determine the weight of the sample. Transfer the contents to an Erlenmeyer flask with 50 c.c. of distilled water and add 10 c.c. of diluted nitric acid and 5 c.c. of ferric alum solution. Titrate with tenth normal potassium thiocyanate solution. The amount of silver found is not less than 28.0 per cent nor more than 32.0 per cent.

Accurately pipet 1 c.c. to a Kjeldahl distilling flask and dilute with distilled water to a volume of 200 c.c. Add 10 c.c. of sodium sulphide solution (10 gm. $Na_2S—9H_2O$ per hundred centimeters) and 20 centimeters sodium hydroxide solution (40 gm. NaOH per hundred centimeters). Connect the flask to a condenser and distil approximately 100 c.c., collecting the distillate in 50 c.c. of half normal hydrochloric acid. Titrate the excess acid with half normal sodium hydroxide using methyl red as an indicator. The percentage of ammonia ($NH_3$) obtained divided into the percentage of silver obtained is not less than 3.10 nor greater than 3.60. The amount of ammonia found is not less than 8.9 per cent nor more than 9.8 per cent.

**Accurately pipet 1 c.c. to an aspirating apparatus.[1] Add 20 c.c. of distilled water. Aspirate for one hour at a lively rate, collecting the aspirated gases in 25 c.c. of fiftieth normal hydrochloric acid. The air used for aspiration is drawn through a soda lime tube, then through fiftieth normal hydrochloric acid and through water to remove traces of carbon dioxide and ammonia in the air. Titrate the excess acid with fiftieth normal sodium hydroxide solution using methyl red as the indicator. Not more than 5 c.c. of fiftieth normal hydrochloric acid is required for neutralizing the "aspirable" ammonia.**

## Colloidal Silver Preparations

The action of silver nitrate is dependent on the ionization of the compound to form silver ions. Because of its irritant action, it has been somewhat replaced in medicine by compounds of silver with different proteins.

In these, the silver does not exist to any great extent as free ions. Therefore, it does not precipitate chlorides or proteins, and is noncorrosive, and, relatively or quite, nonastringent and nonirritant. Nevertheless, a considerable degree of antiseptic action is retained. This is not proportional to the total silver content, and varies for the different compounds. It has been suggested that the antiseptic action is due to the liberation of a very low concentration of silver ions, which vary for the different compounds.

The mechanism of these effects is analogous to the relatively slow action of silver nitrate. This takes place in two stages: (1) the immediate irritant and germicidal actions, and (2) the later, milder antiseptic actions produced by the re-solution of the silver-protein compounds that were formed in the first stage. If the second stage alone is desired (i.e., mild antisepsis without irritation), the direct application of the colloid compounds may have advantages over their indirect production from silver nitrate, aside from the avoidance of irritation. The absence of any coagulation membrane facilitates their access to the cells. They form more concentrated solutions than are likely to be formed from the re-solution of the silver precipitates *in situ*. The colloidal aggregates may be smaller and therefore more reactive, and because of the absence of irritation, they are likely to be more frequently applied and would for that reason secure a more nearly continuous action.

Metallic silver and insoluble compounds of silver, such as the oxide, the halogen salts (iodide, chloride, etc.) and silver protein precipitates, may be brought into "colloidal solution," if they are sufficiently finely divided and they became miscible with water, so that they apparently go into solution (although such "colloidal solutions" are strictly permanent "suspensions" of the insoluble substances in a state of ultra-microscopic particles).

The commercial preparations are for the most part produced by dissolving reduced silver or silver oxide, or some protein-silver precipitate, in an excess of denatured protein and drying *in vacuo*. This results in the formation of substances that dissolve very freely although somewhat slowly, in water, yielding brown "colloidal solutions" which contain so little of free silver ions that they do not readily precipitate chlorides or proteins. They consist probably of indefinite mixtures of metallic silver, silver oxide, and various silver-protein compounds, all in colloidal form. The proportions of these and the properties of the mixture vary according to the conditions under which they are produced. Although there are probably all kinds of gradations, most of the products on the market fall into a small number of fairly definite therapeutic groups: (1) strong silver-protein type; (2) mild silver-protein type; (3) collargol type, and (4) electric type.

**Strong Silver-Protein Type:** Strong silver-protein compounds contain the lowest percentage of silver (from 7.5 to 8.5 per cent), but have the strongest germicidal action, and are distinctly irritant, because they produce more ionizable silver in solution. They are, therefore, therapeutically intermediate between silver nitrate and mild silver-protein. Protargol and proganol belong to this group.

Protargol is said to be prepared by precipitating a "peptone" (albumose) solution with silver nitrate, or with moist silver oxide; dissolving the silver peptonate in an excess of protalbumos, and drying *in vacuo* (Fraenkel).

**Mild Silver-Protein Type:** Mild silver-protein compounds contain from 19 to 25 per cent of

1. Van Slyke & Cullen, J.: Apparatus for Determining Urea Content, J. Biol. Chem., 19:217, 1914. Hawk: Practical Physiological Chemistry, Ed. 7, p. 515.

silver, but are relatively nonirritant. The following products listed belong to this group: argyn, silvol and solargentum-Squibb.

Argyn is defined as a colloidal compound of silver oxide and serum albumin.

Solargentum-Squibb is prepared from alkali-gelatin, used as a solvent for silver oxide. The solution is then concentrated and dried *in vacuo.*

Silvol is a compound of colloidal silver with an alkaline protein.

**Therapeutic Uses:** The colloidal silver compounds are used mainly on mucous membranes, for antisepsis. The strong silver-protein group is most effective in this respect, but is slightly irritant and stimulant. The mild silver-protein group acts also largely as a mucilaginous demulcent and protective; and as a detergent, by dislodging pus.

**Dosage and Administration:** The concentration for mucous membranes range from 0.1 to 10 per cent for strong silver-protein; and from 5 to 50 per cent for mild silver-protein. They are applied every two to four hours, if possible. Solutions should be recently prepared, and should be protected against light. Ointments and suppositories are used with the same concentrations as the aqueous solutions. Stains on linen are removed by 1:1,000 solution of mercuric chloride.

**STRONG SILVER-PROTEIN, U.S.P.**—Argento-proteinum forte (Arg.-prot. fort.) Protargin strong. A colloidal compound of silver oxide and protein containing 7 to 8.5 per cent of silver. The brands described differ somewhat in composition, but are essentially equivalent therapeutically.

**Properties:** Strong silver-protein usually occurs as a brown powder, freely but slowly soluble in water (about 1:2) forming colloidal solutions. It is also soluble in glycerine, but insoluble in alcohol and oils. Solutions are dark, but less deeply colored than solutions of mild silver-protein). Solutions are best prepared by sprinkling the substance on distilled water and allowing solution to take place spontaneously.

**Incompatibilities:** It is incompatible with acids and concentrated salt solutions.

**Actions, Uses and Dosage:** (See preceding article on silver compounds.)

**Protargol:** A brand of strong silver-protein U.S.P. Protargol is a compound of albumin and silver.

Manufactured by Winthrop Chemical Co., Inc., New York. U.S. patent expired. U. S. trademark 30,882.

**MILD SILVER-PROTEIN, U.S.P.**—Argento-proteinum mite (Arg.-prot. mit.) (Protargin mild).—A colloidal compound of silver oxide and a protein derivative containing from 19 to 30 per cent of silver. The brands of mild silver-protein differ somewhat in composition, but are essentially equivalent therapeutically. The following brands are included: argyn, silvol and solargentum-Squibb.

**Properties:** Mild silver-protein occurs in dark brown or almost black lustrous scales or granules freely soluble in water, forming deeply colored colloidal solutions. It is also soluble in glycerine, but insoluble in alcohol and oils.

**Incompatibilities:** It is incompatible with acids and strong solutions of salt.

**Actions and Uses:** (See preceding article on silver compounds.)

**Dosage:** Mild silver-protein is usually employed in concentrations of 50 per cent, which are used several times daily. Solutions of mild silver-protein should be prepared fresh and dispensed in amber-colored bottles.

**Argyn:** A brand of mild silver-protein, U.S.P. Argyn is a colloidal compound of silver oxide and serum albumin.

Manufactured by the Abbott Laboratories, North Chicago, Ill. No U.S. patent. U.S. trademark 137,522.
*Argyn Tablets, 6 grains.*

**Silvol:** A brand of mild silver-protein U.S.P. Silvol is a compound of colloidal silver with an alkaline proteid.

Manufactured by Parke, Davis & Co., Detroit, Mich. No U.S. patent or trademark.

**Solargentum-Squibb:** A brand of mild silver-protein U.S.P. Solargentum-Squibb is a compound of silver and gelatine, containing from 19 to 23 per cent of silver in colloidal form.

Manufactured by E. R. Squibb & Sons, New York city. No U.S. patent or trademark.
*Tablets Solargentum-Squibb, 4.6 grains*

**NEOSILVOL.**—Colloidal silver iodide compound.—A compound of silver iodide with a soluble gelatine base containing from 18 to 22 per cent of silver iodide in colloidal form.

**Actions and Uses:** Neosilvol, even in concentrated solutions, causes neither irritation of mucous membranes nor coagulation of albumin. It does not stain the skin.

It is maintained that neo-silvol, in laboratory tests for germicidal value, has been found as effective as phenol in its action on bacteria.

Neosilvol is intended for the prophylaxis and treatment of infections of accessible mucous membranes and is said to be indicated in infections of the eye, ear, nose and throat.

**Dosage:** In the treatment of acute inflammations of the mucous membranes, solutions of neosilvol as strong as 50 per cent can be used. For irrigating the sinuses, from 2 to 5 per cent solutions are used.

Solutions of neosilvol are prepared by adding the substance to the required amount of water and agitating the mixture until solution occurs.

Manufactured by Parke, Davis and Co., Detroit, Mich. U. S. patent and trademark applied for.
*Capsules Neo-Silvol, 6 grains.*

Neosilvol is prepared by heating freshly precipitated silver oxide with gelatine which has been previously dissolved in a dilute alkaline solution, until the silver oxide has been reduced to metallic silver in a colloidal state of subdivision. The solution is treated with iodine, which combines with the silver. The liquid is then evaporated to dryness *in vacuo*. The finished product contains from 1 to 3 per cent of combined iodine in excess of that required for combination with the silver.

Neosilvol occurs as pale yellow granules. In concentrations up to 50 per cent, neosilvol forms with water an almost colorless, milky or opalescent solution (colloidal suspensions). Neosilvol is insoluble in fixed oils, but slowly soluble in glycerine. Solutions of neosilvol are not precipitated in the cold by strong acids or sodium chloride, and they tend to precipitate on standing.

## SOAP

Soap is the product formed by the action of alkalis on animal or vegetable fats (saponification).

Soap is used principally as a detergent. The detergent action is obtained only by the use of the soluble soap; that is, of salts of the higher fatty acids (oleic, palmitic, and stearic) with sodium or potassium. When solutions of soluble soap are brought in contact with the soluble salts of the alkaline earths, insoluble soaps are precipitated. This is commonly observed when soap is used with hard water and thus represents one of the common incompatibilities of soap and seriously interferes with its detergent action.

**Action and Uses:** Soap is used as a detergent either alone or combined in the form of tooth pastes or powders. The detergent action of soaps are at present not clearly understood. It is held that their action is due to hydrolysis of the soap yielding a store of alkali or to the colloidal dispersion of the liberated fatty acid.

**SOAP, U.S.P.**—(Olive oil castile soap.)—Soap prepared from sodium hydroxide and olive oil. (Castile soap.)

**Properties:** Soap occurs as a white or nearly white solid, hard, yet easily cut when fresh; or as a fine yellowish white powder, having a faint peculiar odor free from rancidity; a disagreeable alkaline taste, and an alkaline reaction. It is soluble in water and in alcohol.

**SOFT SOAP, U.S.P.**—Sapo mollis (Sapo moll.)—A soap prepared from linseed oil, potassium hydroxide, sodium hydroxide and glycerine and water.

**Properties:** Soft soap occurs as a soft, unctuous, yellowish white to yellowish brown mass, having a characteristic odor and an alkaline taste.

**Actions and Uses:** Soft soap is used principally as a detergent. Being soluble in alcohol, and in mixtures of alcohol and water, it is frequently used as a liquid soap. A convenient form is the "tincture of green soap," linimentum saponis mollis, U.S.P., an alcoholic solution containing about 65 per cent of soft soap, perfumed with oil of lavender.

**SODIUM BICARBONATE, U.S.P.**—Sodii bicarbonas (sod. bicarb.) $NaHCO_3$.

**Properties:** Sodium bicarbonate occurs as a white, opaque powder, odorless and having a cooling mildly alkaline taste. It is soluble in water (1:10) at 15 C., and practically free from decomposition, but, above this temperature, the solution gradually loses carbon dioxide, and, at the boiling point of water, the salt is converted into normal carbonate. It is practically insoluble in alcohol.

**Incompatibilities:** Sodium bicarbonate is incompatible with acids and acid salts. Its solutions should be made with cold water, as heat converts a part of the bicarbonate into the carbonate.

**Actions and Uses:** Because sodium bicarbonate hydrolzes into sodium carbonate and sodium hydroxide, it possesses some of the properties of each of these. The pharmacologic action of sodium carbonate is therefore due to its powers of neutralizing acids and of dissolving proteins

and also to its ability to saponify fats. Sodium bicarbonate is useful as an antacid for neutralizing excess acids used in root-canal work. Contrary to earlier suppositions, large amounts of sodium bicarbonate in solution do not cause any appreciable influence in altering the hydrogen-ion concentration of the saliva. Sodium bicarbonate seems to be useful in tooth powders and pastes because of its detergent properties.

Sodium bicarbonates alone or in combination with bismuth subcarbonate and magnesia is used internally to overcome the acid of the gastric juice in hyperacidity and dyspepsia. It is a constituent of Dobell's solution.

**SODIUM BORATE, U.S.P.**—Sodii boras (sod. bor.) (borax, sodium tetraborate, sodium pyroborate) $Na_2B_4O_7.10H_2O$.

**Properties:** Sodium borate occurs as colorless, transparent crystals or a white powder, nonodorous and having a sweetish alkaline taste. It is soluble in water (1:15), but insoluble in alcohol.

**Incompatibilities:** Sodium borate is decomposed by mineral salts and is incompatible with the metallic salts of the mineral acids and with the salts of most alkaloids.

**Actions and Uses:** There are no indications for the internal use of sodium borate. Indeed, large doses may lead to toxic effects. (See boric acid.) Sodium borate, like boric acid, combines a fair antiseptic power with a low toxicity. It is also detergent. It is a component of many proprietary mouth washes; and is a compound of Dobell's solution (N.F.V.)

| ℞ | Gm. | C.c. |
|---|---|---|
| Sodium bicarbonate | 4.0 | |
| Sodium borate | 4.0 | |
| Phenol crystals | 2.0 | |
| Glycerine | | 30.0 |
| Water | | 1 liter |

For the purpose of a general mouth wash, a 2 per cent solution in water may be used. A mixture of equal parts of borax, salt and sodium bicarbonate has been suggested as a mouth wash or dentifrice. Whether such a mixture possesses advantages over each single constituent is not known.

The action of sodium borate is very similar to that of boric acid, for which it is often substituted. In saturated solution, it can be used in cases of stomatitis and thrush. For infants with thrush, a saturated solution in glycerine may be applied by a swab to the mouth. (See boric acid for "borism.") A saturated solution in 10 per cent formaldehyde may be used as a sterilizing fluid for small instruments. (Borax prevents the attack of metal by formaldehyde.)

**COMPOUND SOLUTION OF SODIUM BORATE, N.F.V.**—Liquor sodii boratis compositus (liq. sod. bor. co.) (Dobell's solution.) Sodium borate and sodium bicarbonate (each 1.5 per cent) and liquefied phenol (0.3 per cent) in glycerine and water.

**Uses:** Mild antiseptic. It may be used as a spray, mouth wash or gargle.

**SODIUM CHLORIDE, U.S.P.**—Sodii chloridum (sod. chlorid.) (common salt)—NaCl.

**Properties:** Sodium chloride occurs as colorless, cubical crystals or as a white crystalline powder, odorless and having a purely saline taste. It is freely soluble in water (1:3) and nearly insoluble in alcohol.

**Incompatibilities:** Sodium chloride is incompatible with salts of silver and lead.

**Actions and Uses:** Sodium chloride is used for preparing physiologic solution of sodium chloride; 8.5 gm.:1,000 c.c. of distilled water. The solution is sterilized by heat (liquor sodii chloridi physiologicus, U.S.P.) This solution is frequently referred to as normal salt solution, but it should not be confused with the chemical normal solution of sodium chloride. When given by mouth in large doses, sodium chloride is emetic, and, in proper dilution, laxative.

Isotonic solutions are used as a medium for cleansing sensitive mucous membranes.

The following recipe is an example of a pleasantly flavored mouth rinse when dissolved in water:

| ℞ | Gm. | C.c. |
|---|---|---|
| Sodium chloride | 30 | |
| Sucrose | 20 | |
| Oil of cinnamon | | 0.25 |
| Oil of cloves | | 0.50 |
| Oil of peppermint | | 0.25 |

Sodium chloride is used alone or mixed with chalk and other materials as a dentifrice. Caution should be exercised in dispensing sodium chloride dentifrices (containing water) in tin tubes, because of the corrosive action of sodium chloride on tin. The feeling of stimulation claimed to be produced is probably due to the mild irritant properties of the salt or the salt solution on the mucous membranes. Although common salt has been advocated as a useful dentifrice, there is no adequate evidence either clinical or laboratory upon which this advocacy is based. In substance, it represents an economical dentifrice.

**STRYCHNINE SULPHATE, U.S.P.**—Strychninae sulphas (strych. sulph.)—The sulphate of an alkaloid obtained chiefly from nux vomica.

**Properties:** Strychnine sulphate occurs as colorless or white prismatic crystals, or a white crystalline powder, odorless and having an intensely bitter taste. It is said to be the bitterest known alkaloid. It is efflorescent in dry air and soluble in water (1:35) and in alcohol (1:81).

**Incompatibilities:** The salts of strychnine are incompatible with alkalis, alkali carbonates, iodides, bromides, arsenates and arsenites.

**Actions and Uses:** Strychnine stimulates the spinal cord, increasing its reflex excitability, but it has little effect on the centers above the medulla. It stimulates the respiratory center, increasing the rate of respiration, but the effect is only temporary. Toxic doses raise the blood pressure by stimulating the vasoconstrictor center and also by increasing the output of epinephrine from the suprarenals. It has little action on the heart. Poisonous doses cause tetanus, but the trismus is not marked. Between attacks, there is usually complete relaxation of the affected muscles.

Strychnine is used as a bitter tonic, generally in the form of a preparation of nux vomica. It is also a tonic to the muscular system because of the increased response to stimuli which it induces. It has been used widely as a respiratory and circulatory stimulant in pneumonia and other infections, and shock, but nontoxic doses are ineffective. It has been widely recommended for the treatment of shock due to anesthesia by hypodermic injection.

**Dosage:** 0.002 gm. (one-thirtieth grain).

**TRICHLOROETHYLENE.** — Trichloroethylenum. — Trichlorethylene. — $CHCl:CCl_2$. — 1-chloro-2-dichloro-ethylene.

**Actions and Uses:** The action of trichloroethylene has not been investigated comprehensively. It was introduced into therapeutics after some observations on man. Trichlorotheylene appears to have an action on the sensory endings of the trigeminal nerve, whereby it affords relief in trigeminal neuralgia, but it is not clear that the action even of therapeutic doses is limited to these endings. Different individuals seem to show rather wide variations in susceptibility to this action, and the dose necessary to afford relief varies correspondingly. Therapeutic doses sometimes cause transitory giddiness, with lassitude, distress, palpitation and nausea. Large doses cause narcosis, and excessive doses cause death. There was no perceptible injury to the lungs, heart or liver after narcosis repeated several times in the dog, but there was slight hyperemia of the gastric mucous membrane and marked reddening of the duodenum. The liquid is irritant; hence, it should not be allowed to come in contact with the nose when the vapor is inhaled.

**Dosage:** Fifteen minims by inhalation, to be repeated after a few minutes if necessary. It appears probable that no more than 60 minims should be inhaled within twenty-four hours when it is used for any considerable period of time.

Trichloroethylene occurs as a clear colorless mobile and volatile liquid possessing an odor similar to that of chloroform. It is miscible with ether and very soluble in alcohol. It is practically insoluble in water. The specific gravity is from 1.458 to 1.460 at 25 C. The refractive index is from 1.4770 to 1.4780 at 20 C.

Transfer 25 c.c. trichloroethylene to a distilling flask. Determine the distillation range according to method 1 of U. S. Pharmacopeia X. Ninety-five per cent distils over at from 86 to 88 C. (corrected) at 760 mm. The refractive index of the distillate is the same as that of the material before distillation.

Transfer 5 c.c. of trichloroethylene to a glass stoppered cylinder, add 5 c.c. bromin water and shake the mixture vigorously at intervals of fifteen minutes; at the end of an hour, a white turbid solution forms in the lower layer. Agitate gently 5 c.c. of trichloroethylene with 2 c.c. of silver ammonium nitrate solution in a narrow glass stoppered cylinder of from 10 to 15 c.c. capacity. No turbidity is observed in either layer at the end of ten minutes (acetylene).

Agitate 20 c.c. of trichloroethylene with a 50 c.c. portion of water and repeat, using a 25 c.c. portion of water. Transfer the combined aqueous layer to a flask and add to the aqueous solution 2 drops of methyl red indicator solution. If the solution is yellow, the addition of not more than 0.1 c.c. of tenth normal hydrochloric acid is required to make it pink. If the solution is pink, the addition of not more than 0.1 c.c. of tenth normal sodium hydroxid will make it yellow.

Agitate 10 c.c. of trichloroethylene with 25 c.c. of water and allow the liquid to separate completely. Separate 10 c.c. portions of the aqueous layer are affected as follows: No turbidity is noted five minutes after the addition of 0.1 c.c. of nitric acid and 0.1 c.c. of silver nitrate solution (chlorides). No blue is observed after the addition of 0.1 c.c. of potassium iodide test solution and 0.1 c.c. of starch test solution (readily oxidizing substances such as free chlorine). Add 0.1 c.c. of alcohol to 5 c.c. of trichloroethylene. A turbid solution is formed (distinction from chloroform).

Evaporate 25 c.c. of trichloroethylene in a platinum or porcelain dish on a steam bath and dry to constant weight at 100 C. No weighable residue is obtained.

**Trichlorethylene-Calco:** A brand of trichloro-ethylene.

Manufactured by Calco Chemical Co., Inc., Bound Brook, N. J. No U.S. patent or trademark.
*Tubes Trichlorethylene-Calco, 1 c.c.* Each trade package contains twenty-one frangible tubes.

## ZINC COMPOUNDS

The essential action of salts of zinc, like those of copper and silver, is that of an astringent or corrosive. The action of these salts being largely proportional to the concentration, strong solutions of zinc chloride have been used as an escharotic, fairly strong solutions of zinc sulphate as an emetic, weaker solutions of zinc sulphate and zinc acetate as astringent and antiseptic applications to the mucous membranes of the eye, urethra, mouth tissues, etc., while the insoluble zinc oxide is used externally as a mild antiseptic and astringent. Zinc oxide is the base of many dental cements and filling materials. Zinc oxide in combination with eugenol and vegetable oils or liquid petrolatum has been suggested as a surgical packing to be applied after radical operations for pyorrhea. The cement thus formed is said to protect the wounded areas and also to serve as a splint for the teeth.

Various zinc salts containing therapeutically active acid radicals or anions have been used in medicine. It is questionable whether any zinc salt possesses advantages not possessesed by any other. The astringent properties of zinc salts have been used in the treatment of stomatitis, aphthae, ulcer, etc. Zinc phenolsulphonate was introduced in the belief that the phenolsulphonate radical would impart antiseptic properties different from the other zinc salts, but experience has not supported this view. There is no convincing evidence available that zinc iodide possesses advantages over zinc chloride as an astringent. Experience has not borne out the early hopes that it combines the astringent properties of zinc and the antiseptic properties of iodine. It was official in the U.S.P. IX, but has been deleted from the current edition.

**ZINC CHLORIDE, U.S.P.**—Zinci chloridum (zinc chlor.) $ZnCl_2$.

**Properties:** Zinc chloride occurs as a white or nearly white granular powder or in porcelain-like irregular masses, or molded into pencils, odorless, and so intensely caustic as to make tasting dangerous, unless freely diluted with water. The dilute solution has an astringent, metallic taste. It is very soluble in water (1:0.25) and in alcohol (1:1.3).

**Incompatibilities:** Zinc chloride is incompatible with sodium borate and with alkali carbonates.

**Actions and Uses:** Zinc chloride is used as an antiseptic, astringent and escharotic. It is used for reducing hypersensitive dentin on anterior teeth, where the discoloration produced with silver nitrate would be objectionable. It is claimed to be not so effective as the latter. For this purpose, it is applied in concentrated solution as liquor zinci chloridi or in substance. It is also used as a constituent of many mouth washes of an astringent nature. An 8 per cent solution is used by some as an astringent in the treatment of various forms of pyorrhea. Zinc sulphate would probably be less irritating. The zinc chloride "mouth washes" have been over-exploited. A 1:2,000 to 1:500 zinc chloride solution has a very poor germicidal and feeble antiseptic action, though it is a fair deodorant. The daily use of a mouth wash containing zinc chloride for so-called oral hygiene cannot be considered rational.

**SOLUTION OF ZINC CHLORIDE, U.S.P.**—Liquor zinci chloridi (liq. zinc. chlor.)—

An aqueous solution containing about 50 per cent by weight of zinc chloride made by dissolving granulated zinc in hydrochloric acid.

**ZINC OXIDE, U.S.P.**—Zinci oxidum (zinc. oxid.) ZnO.

**Properties:** Zinc oxide occurs as a very fine, amorphous, white or yellowish white powder, free from gritty particles, without odor or taste. It is insoluble in water and in alcohol.

**Incompatibilities:** Zinc oxide is incompatible with acids.

**Actions and Uses:** Zinc oxide is not used internally. It is slightly antiseptic and feebly astringent. It is used in combination with eugenol as a temporary covering for exposed pulps, to hold medicinal agents in the tooth. While zinc oxide and eugenol will fulfil all essential purposes, various products containing potential antiseptics, such as silver salts, and bismuth subnitrate and other products, are marketed under diverse names, but these have not been shown to possess any advantage. The use of antiseptics for pulp capping and temporary cements is irrational because zinc oxide itself is potentially antiseptic and because the zinc oxide cement is used primarily for mechanical purposes. Zinc oxide itself is practically nontoxic. It forms the base of various cements employed in dentistry, such as zinc oxychloride and zinc oxyphosphate, which are used as temporary fillings and to retain medicinal applications in the tooth.

Compounded with resin in equal parts, and mixed with a liquid composed of eugenol and liquid petrolatum or olive oil, it is claimed to be useful as a postoperative pack after surgical treatment of the gums for pyorrhea.

**ACETONE, U.S.P.**—Acetonum (aceton.) (dimethyl-ketone) $CH_3CO.CH_3$.—A colorless liquid with an ethereal odor and a pungent sweetish taste; miscible with water, alcohol, ether, chloroform and most volatile oils.

**Action and Uses:** Pharmaceutic solvent. It is used as a solvent for resins, rubber and celluloid-like materials. It is also used as a dehydrating agent for root-canal work.

## ACIDS

Acids may, for convenience of discussion, be divided into two main groups: inorganic and organic acids, but most of them owe their activity on protoplasm to the hydrogen ions liberated in solution. Some acids, such as salicylic acid, acetylsalicylic acid and tannic acid, are not dependent for their pharmacologic action on the hydrogen ion, but on the rest of the molecule. Both inorganic acids and many organic acids are corrosive, depending on the concentration. Dilute acids alter the surface charges and the solubility of colloids, and produce stimulation and irritation. Concentrated acids destroy the tissues by direct chemical action and are therefore corrosive. The concentrated acids have an affinity for water and withdraw this from cells. This affinity is so strong in the case of concentrated sulphuric acid that not only is water withdrawn from the tissue, but also carbonization may follow.

Most soluble acids and acid salts dissolve calcareous material, such as bone and teeth. Sulphuric acid and acids which form insoluble calcium salts are limiting in their action. This action forms the basis of treating root canals with sulphuric or phenol sulphonic acids. Chromic acid, if not used judiciously, may cause poisoning.

**Actions and Uses:** Because of the intense pain, deep penetration and extensive scar formation, acids are not desirable cauterants. Because nitric and trichloracetic acids form relatively firm eschars, their action is more circumscribed and less painful. Glacial phosphoric acid in combination with some form of sodium phosphate is used as a component of dental cements. Hydrochloric acid and citric acid have been found to be the main constituents of certain tartar removers, and their use for such purposes is potentially harmful. (*J. Dent. Res.*, 10:481 [Aug.] 1930.)

**BORIC ACID, U.S.P.**—Acidum boricum (acid. bor.) (boracic acid) $H_3BO_4$.

**Properties:** Boric acid occurs as transparent, colorless scales, or a light, unctuous, very fine powder. It is odorless, has a faintly bitter taste and is slowly soluble in water (1:18), soluble in alcohol (1:18), freely soluble in glycerine (1:4) and freely soluble in boiling water.

**Action and Uses:** Boric acid is a mild antiseptic and astringent. It is the only mineral acid which is known not to affect tooth structure. It is more active on molds and fission fungi than on pathogenic bacteria. Externally, it is used frequently as a dusting powder, either alone or combined with diluents such as starch and talcum, or with active substances such as salicylic

acid and iodoform. It is also widely used as a wash or lotion, especially for catarrh of the mucous membranes, pharyngitis, etc., usually in simple aqueous solutions of from 2 to 4 per cent strength. The glycerite of boroglycerine is employed in washes and injections. The ointment is mildly antiseptic, but it is used chiefly as a protective dressing. It should not be used with calcium carbonate because it reacts with it to form calcium borate and then calcium hydroxide. Boric acid is a constituent of many mouth washes. Repeated applications of boric acid lead to a condition known as "borism." Hence, the free use of boric acid solutions or solutions of borates should be guarded against, particularly in children's mouths, because of the possible danger of "borism" that may arise through reflex swallowing.

**GLYCERITE OF BOROGLYCERINE, U.S.P.**—Glyceritum boroglycerini (glycer. boroglyc.) A glycerine solution of boroglycerine (glyceryl borate), representing 31 per cent of boric acid.

**LIQUOR ANTISEPTICUS, N.F.V.**—(Liq. antisept.) Antiseptic solution. Boric acid (2.5 per cent), thymol, eucalyptol, methyl salicylate, oil of thyme and menthol in water and alcohol, and also benzoic acid.

**BENZOIC ACID, U.S.P.**—Acidum benzoicum (acid. benz.) $C_6H_5COOH$. Lustrous, almost colorless scales or needles, with a pungent, acid taste. Slightly soluble in water (1:275) and freely soluble in alcohol (1:2.3); also readily soluble in solutions of alkali hydroxides or carbonates with the production of alkali benzoates.

**Actions and Uses:** Antiseptic, diuretic and sialogogue. When it is a constituent of mouth washes and dentifrices, it is usually used as sodium benzoate. It should not be employed in dentifrices containing calcium carbonate because it reacts on carbonates and bicarbonates in the presence of moisture.

**NITRIC ACID, U.S.P.**—Acidum nitricum (acid. nitric.) A liquid containing about 68 per cent by weight of hydrogen nitrate ($HNO_3$). Diluted nitric acid is 10 per cent by weight of absolute nitric acid.

**Properties:** Nitric acid is a colorless, fuming, very caustic and corrosive liquid, having a peculiar and somewhat suffocating odor. It is miscible with water in all proportions. Nitric acid dissolves mercury and most other metals with the evolution of brown fumes. It stains woolen fabrics and animal tissues a bright yellow.

**Incompatibilities:** Like other inorganic acids, it is incompatible with alkalis, the alkali carbonates and many of the salts of inorganic acids and, because of its oxidizing properties, with all readily oxidizable substances. Its addition to organic liquids (alcohol, etc.) is apt to give rise to explosive reactions.

**Action and Uses:** Nitric acid is a powerful caustic, used for removing warts and small nevi and for cauterizing chancroids and other sores and the wounds made by rabid animals, but its action is very painful and not readily controlled. When nitric acid is used as a caustic, the surrounding healthy tissue should be coated with petrolatum and the acid applied on the end of a glass rod or a splinter of wood. Nitric acid is used in mechanical dentistry as a solvent for dental cements. Porcelain facings and crowns are removed from removable or fixed bridgework by placing the bridge in nitric acid for a few hours. It is also used to clean porcelain before staining and glazing.

**SULPHURIC ACID, U.S.P.**—(Acidum sulphuricum.) Oil of vitriol. It contains 92.5 per cent by weight of absolute sulphuric acid.

**Properties:** An oily colorless liquid which is intensely corrosive. It is miscible in all proportions with water and alcohol.

**Incompatibilities:** It is incompatible with alkalis, alkaline carbonates and iodides.

**Action and Uses:** Sulphuric acid is not used internally in dentistry. A 30 per cent solution of it is used to enlarge small and tortuous root canals. Twenty-five per cent solutions of sulphuric acid are used as a "pickle" to remove oxidized surfaces from gold after soldering or casting.

Phenolsulphonic acid in 80 per cent solution is sometimes used instead of sulphuric acid in root-canal treatment. It is oilier and hence more easily adherent to the broach.

**TRICHLORACETIC ACID, U.S.P.**—Acidum trichloraceticum (acid. trichloracet.) $CCl_3COOH$. Colorless, deliquescent crystals with a slight characteristic odor. It is miscible with water, alcohol and ether.

**Action and Uses:** It is a caustic used for the removal of polypi, hyperplastic gum or pulp tissue, granulation areas, etc. It has been used in weak solutions (from 5 to 10 per cent) in the treatment of so-called pyorrheal pockets.

## Tannic Acid Derivatives

The pharmacologic actions of tannic acid are due to its property of precipitating protein. Advantage is taken of this property in using tannic acid as an astringent. In concentrated solution, it may act as an irritant and even as a cathartic. Internally, tannic acid has been used in diarrhea, but if tannic acid is given as such, it is rapidly dissolved in the stomach, and may then produce excessive gastric irritation, nausea and even vomiting. Many synthetic preparations analogous to tannic acid have been introduced to overcome these objectionable features. It is probable that this object has not been fully attained.

These types of tannic acid are four in number: (1) organic esters of tannic acid, represented by acetyltannic acid (acetyltannic acid U.S.P., tannigen); (2) coagulated tannin proteinate, represented by exsiccated tannin albuminate (albumin tannate U.S.P.); (3) tannin caseinate (protein), and (4) a heterogenous group of other compounds, such as bismuth salts of tannic acid. The chief criteria for evaluating the tannic acid compounds are their degrees of solubility or speed of hydrolysis during various reaction periods in acid and alkaline solution, with or without the addition of ferments. For the purpose of dental therapeutics, they present no advantage over tannic acid, which is official in the Pharmacopeia.

**TANNIC ACID, U.S.P.**—Acidum tannicum (acid tann.) (Tannin, gallotannic acid). A tannin usually obtained from nutgalls.

**Properties:** Tannic acid occurs as a light yellowish, amorphous powder, gradually turning darker when exposed to air and light. It has a faint characteristic odor and a strongly astringent taste. Tannic acid is very soluble in water, alcohol and glycerine.

**Incompatibilities:** It is incompatible with alkalis, alkaloids, salts of iron and of most other metals, albumin and gelatin. It reacts with alkaloids and the salts of the heavy metals to form insoluble compounds.

**Action and Uses:** Tannic acid is used as an astringent and hemostatic. Internally it has been employed chiefly in the treatment of diarrhea, preferably in the form of acetyltannic acid or gambir, U.S.P., because free tannic acid irritates the stomach and may cause nausea and vomiting. Local applications of a 0.5 to 1 per cent solution of tannic acid are used as astringents on inflamed mucous membrane, especially in pharyngitis. It is a constituent of many mouth washes.

**Dosage:** 2 to 10 grains.

**GLYCERITE OF TANNIC ACID, U.S.P.**—Glyceritum acidi tannici (Glycer. acid. tann.) Glycerite of tannin. A 20 per cent solution of tannic acid in glycerine.

**Dosage:** This preparation is chiefly used externally and affords a convenient agent for making dilute solutions for local use. For local applications, solutions containing from 0.5 to 2 per cent of tannic acid are appropriate.

**ACONITE, TINCTURE OF, U.S.P.**—Tinctura aconiti (tr. aconit.) (aconiti tinctura, P.I.) One hundred centimeters represents approximately 10 gm. of the drug in about 63 per cent alcohol. Assayed biologically, the minimum lethal dose is approximately 0.0004 c.c. for each gram of body of guinea pig.

**Dosage:** Locally, the tincture may be applied cautiously over the course of the affected nerve, or a liniment containing 10 per cent of the tincture may be prescribed. The local application of considerable amounts of undiluted tincture is dangerous, as too much may be absorbed. Caution should be used in its application to mucous membrane. The practice of diluting tincture of iodine with tincture of aconite has nothing to recommend it. Its use in mouth washes is potentially dangerous.

**Action and Uses:** Aconite is a powerful poison. It is a true circulatory depressant; also a nerve sedative. Application to mucus membranes causes, first, irritation, and then depression of the sensory nerve-endings. It causes a fall of temperature. It is used in treatment of apical pericementitis and facial neuralgia. Precaution should be taken in applying the tincture to the posterior teeth lest the patient swallow it.

**ACONITE, COMPOUND DENTAL LINIMENT OF, N.F.V.**—Tincture of aconite containing in each hundred centimeters, 36.0 gm. of menthol and 13.5 c.c. of chloroform.

**Actions and Uses:** Compound liniment of aconite used as a counterirritant for relieving pain involving the gums.

**ACONITE AND IODINE, COMPOUND DENTAL LINIMENT OF N.F.V.**—Tincture of aconite containing in each hundred centimeters, 2.2 gm. menthol, 2.2 gm. iodine and 16.5 c.c. chloroform.

**Action and Uses:** It is used on gums as a refrigerant counterirritant.

**ALCOHOL, U.S.P.**—(Ethanol.) Alcohol contains not less than 92.3 per cent by weight, corresponding to 94.9 by volume, of ethyl hydroxide ($C_2H_5OH$).

**Properties:** Alcohol is a colorless volatile liquid having a characteristic odor and burning taste. It is miscible in all proportions with water, ether or chloroform. In addition to alcohol, the U.S.P. also describes dehydrated alcohol, used as a laboratory reagent, and also diluted alcohol (approximately 50 per cent) used in pharmacy as a menstruum.

**Action and Uses:** Externally, alcohol is a rubefacient and astringent and by its evaporation, a refrigerant. It is used to harden and cleanse the skin and as a mild counterirritant (soap liniment). In the concentration of 70 per cent it is antiseptic and it is employed, in surgery especially, to cleanse the skin of the patient and operator.

Internally, alcohol is a narcotic. Excessive doses depress and paralyze the central nervous system. Small doses produce euphoria, stimulate respiration reflexly, dilate the cutaneous and splanchnic vessels moderately and increase the circulation.

Alcohol is employed as a diffusible stimulant, diaphoretic, hypnotic and antihydrotic. In patients accustomed to its use, it may be very valuable. Otherwise, it is apt to do more harm than good. It is usually administered in the form of whiskey, brandy or wine.

Alcohol is used as a solvent in pharmacy, and, in the form of aromatic elixir, as a vehicle for medicines.

Alcohol may also be used as a desiccant in the preparation of cavities and in root-canal therapy. Ninety-five per cent alcohol is useful in removing the "gelatinous" coating found on teeth and for sterilizing cavities in vital teeth. Where a substitute is desired, 70 per cent to which 1 gm. thymol per fluid ounce is added or a 10 per cent alcoholic solution of phenol is useful.

**AMMONIA, $NH_3$.**—An irritating gas, soluble in alcohol, which is converted into ammonium hydroxide ($NH_4OH$) when dissolved in water. Ammonia water and the several preparations containing it are alkaline.

**Incompatibilities:** It is incompatible with acids, neutralizing them and forming ammonium salts. It is also incompatible with the soluble salts of many metals because it precipitates from these solutions the hydroxides of the metals. Thus, ammonia water with a solution of ferric chloride produces an insoluble precipitate of ferric hydroxide. Solutions of ammonia are also incompatible with the salts of alkaloids, from which they liberate the alkaloid.

**Action and Uses:** Internally, ammonia in the form of ammonia water, or preferably of aromatic spirits of ammonia, is a stimulant, because the escaping ammonia irritates the mucous membranes of the nose and of the stomach and causes a reflex increase in the force of the heart and in the blood pressure. Inhalation of the vapor from ammonia water is a useful remedy in syncope, collapse and other forms of sudden heart failure. Little if any of the gas is absorbed by the respiratory tract.

Externally, ammonia is used as a rubefacient, chiefly in the form of liniment. Applied in concentrated solution, it is apt to cause blistering especially if evaporation is prevented.

**Dosage:** 1 c.c. or 15 minims.

**AMMONIA WATER, U.S.P.**—Aqua ammoniae (aq. ammon.) (solution of ammonium hydroxide).—An aqueous solution containing about 10 per cent by weight of ammonia ($NH_3$).

**Properties:** Ammonia water is a colorless liquid, having a very pungent, characteristic odor and a caustic, soapy taste. It is freely miscible with water and alcohol. On standing, this solution loses ammonia gas, and hence should be kept in well-stoppered bottles and should be tested frequently.

**AMMONIUM CARBONATE, U.S.P.**—Ammonii carbonas (ammon. carb.) It consists of a mixture of ammonium acid carbonate and ammonium carbamate in varying proportions, and yields about 31 per cent of ammonia ($NH_3$).

**Properties:** It occurs as white, hard masses, having a strong odor of ammonia and a sharp,

saline taste. On exposure to the air, the salt loses both ammonia and carbon dioxide. Ammonium carbonate is slowly but freely soluble in water (1:4), the ammonium carbamate being thereby converted into normal ammonium carbonate. Alcohol dissolves the carbamate and leaves the acid carbonate.

**Incompatibilities:** Ammonium carbonate is incompatible with acids, which decompose it, forming salts of ammonium and evolving carbon dioxide ($CO_2$). It precipitates the carbonate or the hydroxide of most metals and the insoluble alkaloids from solutions of their salts.

**Action and Uses:** Ammonium carbonate is largely decomposed (hydrolyzed) when dissolved in water, and its solutions are irritant to mucous membranes from the action of the ammonia set free. It is used by inhalation or in solution as a reflex or diffusible stimulant in syncope, or arrest of respiration, and as a liquefying expectorant in bronchitis.

**Dosage:** 0.3 gm. (5 grains) dissolved in sufficient water (about one tablespoonful) to avoid too great irritation, which may result in nausea and vomiting. On the other hand, as the action of the remedy depends on its irritating qualities, it should not be too greatly diluted. Syrup of glycyrrhiza forms a suitable vehicle for it.

**AROMATIC SPIRIT OF AMMONIA, U.S.P.**—Spiritus ammoniae aromaticus (sp. ammon. arom.)—One hundred centimeters contains 34 gm. of ammonium carbonate, with some free ammonia and aromatic oils in a mixture of distilled water and alcohol.

**Action and Uses:** A useful reflex stimulant, antacid and carminative, having the action and uses of ammonium carbonate combined with those of the alcohol and volatile oils.

**Dosage:** 2 c.c. (30 minims) freely diluted with water. As the stimulating action is of short duration, a moderate dose may be repeated in from fifteen minutes to half an hour.

**BELLADONNA LEAVES, U.S.P.**—Belladonnae folia (bella. fol.) (Deadly nightshade leaves, belladonnae folium, P.I.) The dried leaves and tops of atropa belladonna, assayed to contain not less than 0.3 per cent of belladonna alkaloids.

**Action and Uses:** The actions of belladonna are similar to those of atropine.

**TINCTURE BELLADONNA, U.S.P.**—Tinctura belladonnae (tr. bella.) (Tinctura belladonnae foliorum, U.S.P. IX, belladonnae tinctura, P.I.)—One hundred centimeters represents about 10 gm. of the drug. The tincture is assayed to contain about 0.03 gm. of belladonna alkaloids in 100 c.c.

**Incompatibilities:** The tincture should not be prescribed.

**Dosage:** 0.75 c.c. (12 minims) representing approximately 0.2 mg. (one three-hundredths grain) of mydriatic alkaloids.

**EXTRACT OF BELLADONNA, U.S.P.**—Extractum belladonnae (ext. bellad.) (extractum belladonnae foliorum, U.S.P. IX, belladonnae extractum, P.I.)—A hydroalcoholic extract of belladonna leaves in either a pilular or a powdered form, assayed to contain about 1.25 per cent of belladonna alkaloids. One gram represents about 4 gm. of belladonna leaves.

**Dosage:** 0.015 gm. (one-quarter grain) corresponding approximately to 0.2 mg. (one three-hundredths grain) of mydriatic alkaloids.

**Action and Uses:** It is used for much the same purposes as atropine (which see).

The action of belladonna depends upon the amount of atropine it contains. An extract of belladonna and camphor or other drug is useful for acute coryza.

The application of extract of belladonna to the skin induces a local anodyne effect, which is employed for the relief of rheumatic and neuraglic pains and soreness. Its application in inflammatory conditions induces temporary relief.

**CHLORBUTANOL.**—Chlorbutanol.—Trichlortertiarybutyl-alcohol. Acetonechloroform.—$CCl_3.C(OH).CH_3.CH_3$—1, 1, 1-trichlor-2-methylpropan-2-ol, produced by the reaction of acetone on chloroform.

**Actions and Uses:** Chlorbutanol is a local anesthetic with an action weaker than that of cocaine. It acts on the central nervous system similarly to chloral and although the claim has been made that hypnotic doses are without effect on the circulation and respiration, independent observers have described a fall of blood pressure and interference with respiration in animals and consider it fully as dangerous as chloral. It is more toxic than barbital sodium on oral administration.

It is antiseptic, and as such it is said to be fifteen times as strong as boric acid. It may be used as a preservative for hypodermic solutions. On account of its anesthetic properties, it is

used rather extensively in dentistry in the treatment of exposed and sensitive pulps and as an introductory to general anesthetics to lessen excitement. A solution of chlorbutanol, 8 gm. in oil of cloves, 30 c.c., has been used to relieve "toothache" and as a local analgesic.

**Dosage:** From 0.3 to 1.3 gm. (5 to 20 grains), dry or in capsules. Hypodermically as a local anesthetic, a saturated aqueous solution may be used.

Chlorbutanol is a white, crystalline, volatile compound, having a camphoraceous odor and taste. It is soluble in water (8:1,000), in fixed and volatile oils, and in glycerine; very soluble in alcohol, ether, benzin, glacial acetic acid, chloroform and acetone.

**Chlorbutanol-Merck:** A brand of chlorbutanol.

Manufactured by Merck & Company, Rahway, New Jersey. No U. S. patent or trademark.

**POTASSIUM BICARBONATE, U.S.P.**—Potassii bicarbonas (pot. bicarb.) $KHCO_3$.—Colorless, transparent crystals or white, granular powder, odorless and having a saline, slightly alkaline taste; freely soluble in water (1:2.8) and almost insoluble in alcohol.

**Action and Uses:** Mild alkali; similar to sodium bicarbonate, but without advantage over the latter.

**Dosage:** 1 gm. (15 grains)

**ALKALINE AROMATIC SOLUTION, N.F.**—(Liquor antisepticus alkalinus, N.F. IV) Liquor aromaticus alkalinus (liq. aromat. alk.)—Potassium bicarbonate (2 per cent) and sodium borate (2 per cent), with thymol, eucalyptol, methyl salicylate and cudbear in alcohol, glycerine and water.

**Uses:** Of slight value as antiseptic, but a pleasant cleansing gargle and mouth wash.

**ROSIN, U.S.P.**—Resina (resin.) (colophony)—Rosin is the residue after distillation of the volatile oil from turpentine (the oleoresin).

**Action and Uses:** In general pharmacy, rosin is used in the preparation of ointments and plasters. Rosin applied in chloroform solution is used as a varnish for pulp protection in deep cavities, and as an ingredient of many mixtures for sealing pulp canals. A number of recipes for this purpose have been suggested.

When admixed with zinc oxide in approximately equal parts, it is the basis of many so-called surgical packs. (See under zinc oxide.)

**BALSAM OF PERU, U.S.P.**—Balsamum peruvian (bals. peruv.) Peru balsam—A balsam obtained from a tree, Toluifera pereirae.

**Properties:** Balsam of Peru occurs as a viscid, dark brown liquid, that does not harden on exposure to air. It contains resins and traces of cinnamic and benzoic acids. It is completely soluble in absolute alcohol, chloroform and glacial acetic acid. It is partially soluble in ether and in 5 parts alcohol.

**Action and Uses:** A chloroform solution of balsam of Peru has not been found to possess any advantages over colophony as a varnish for pulp protection and for sealing pulp canals.

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## PREMEDICATION AND POSTMEDICATION FOR DENTISTS AND ORAL SURGEONS

From time to time, the Secretary of the Council receives inquiries concerning the use and prescribing of analgesics, hypnotics and related products. At a recent meeting of the Chicago Dental Society, Stanley W. Clark, professor of oral surgery, Northwestern University Dental School, presented a demonstration on premedication and postmedication in dental practice. The drugs presented and the remarks concerning them are in harmony with the views of the Council. The Council has therefore authorized publication of the material as one method of effectively presenting this type of information. While the Council endorses the presentation, the opinions expressed are those of Dr. Clark and not necessarily the opinions of the Council on Dental Therapeutics.

Lantern slides of this material (pages 529-533) with comments to accompany the individual slides are available at a small rental fee to cover cost of mailing and handling, for those dentists who desire to present this material to their own or other dental groups.

SAMUEL M. GORDON, *Secretary.*

NO. 1.

Medication in the hands of the Dentist or Oral Surgeon reduced to a simple basis.

THE PLAN INCLUDES:

Premedication or Postmedication according to clinical indications.

All drugs suggested are found in:

U. S. P.

N. N. R.

A. D. R.

NO. 2.

There are two main groups in which the Dentist or Oral Surgeon is regularly required to prescribe:

1. ANALGESICS
2. HYPNOTICS

Under *ANALGESICS* may also be considered:

ANTIPYRETICS

ANODYNES

NARCOTICS

Under *HYPNOTICS* may also be considered

NARCOTICS

NO. 3.

*ANALGESICS*

Agents which destroy sensibility to pain.

Greater or more enduring relief from pain is obtained as the charts are ascended in numerical order.

INDICATIONS:

1. For relief from:
   - (a) Simple headache. (Not Migraine)
   - (b) Simple toothache.
   - (c) Pain following ordinary extraction or from a local anesthetic.

*ACETYLSALICYLIC ACID*, U.S.P.
(Aspirin)

Dose 5-10 grains in tablets or capsules.

Where *ACETYLSALICYLIC* ACID irritates the Gastric Mucosa, administer half teaspoonful of *SODA* (Sodium bicarbonate) with each dose.

---

Doctor's Price for 1,000 5 grain tablets $1.65

Cost of Each Tablet ⅛ of a Cent

NO. 4.

(a) For more prolonged relief than is afforded by Acetylsalicylic Acid (Aspirin).

(b) As a substitute for Acetylsalicylic Acid (Aspirin) where the latter irritates the stomach.

*AMIDOPYRINE,* U.S.P.
(Pyramidon)

Dose 5-10 grains, tablets.

No rational reason for administering Aspirin and Pyramidon in the same dose.

Unwarranted mixing of drugs is a reversion to unscientific "shot gun" prescribing.

---

Doctor's Price for
1000 tablets Grains 5
$7.50

Cost of Each Tablet
$\frac{3}{4}$ of a Cent

NO. 5.

(a) Frequently will relieve a profound pain, migraine or neurologic, where Acetylsalicylic Acid (Aspirin) or Amidopyrine (Pyramidon) fail.

(b) Affords more satisfactory relief in surgical cases beyond the simple extraction.

*ACETPHENETIDIN,* U.S.P.
(Phenacetin)

Dose 3-6 grains, tablets, powders, or capsules.

Should be used with discretion.

Is said to be habit forming.

Constant taking may produce an anemia.

Safe to prescribe in therapeutic dosage.

---

Doctor's Price for
1000 3 grain Tablets
$4.35

Cost of Each Tablet
$\frac{4}{10}$ of a cent.

NO. 6.

Frequently more satisfactory relief is gained by combining:

*ACETPHENETIDIN,* U.S.P., grains 3
(Phenacetin)

with

*ACETYLSALICYLIC ACID,* U.S.P., grains 5
(Aspirin)

Powders, tablets or capsules.

The dosage of each may vary somewhat.

A synergistic action is claimed for this combination, but very likely it is merely an Addition Action.

Repeated dosage inadvisable.

4 or 5 doses in 36 hours should be sufficient.

These combined drugs are suggested in place of the

*A* spirin
*P* henacetin
*C* affeine
} —tablet

(This combination of drugs, though widely used, is disapproved by many responsible investigators. It suggests Polypharmacy.)

NO. 7.

For relieving obstinate pain which does not respond to Acetphenetidin (Phenacetin) add ¼ grain

*CODEINE SULPHATE* or *PHOSPHATE* to each dose.

℞ Mr. John Jones,
725 E. 5th Ave.,

| | |
|---|---|
| Acetphenetidini | ʒ ss |
| Codeinae phosphatis | gr. ii ss |

M. Ft. Cap *X*

Sig. Take one (or two) every four hours until pain is relieved.

Reg. No. 2094

James Smith, D.D.S.
122 So. Robey St.

Advisable in cases where patient is confined to home or hospital.

NO. 8.

*HYPNOTICS*

Agents which induce sleep.

SOME INDICATIONS FOR THEIR USE:

(a) Sleeplessness.
Mental strain.
Worry.
Hysteria.
Disturbances of a psychic nature.

(b) Nervous reaction preceding dental or oral surgery operations.

(c) Toxic reaction following introduction of a local anesthetic.

(d) Postoperative discomfiture, with restlessness, sleeplessness, or pain.

NO. 9

The Hypnotic agent of choice is

*BARBITAL SODIUM*, U.S.P.
(Soluble Barbital)
(Veronal-Sodium)

Dose 5-10 grains, tablets, capsules, or powders.

Administration of more than 4 or 5 doses during 48 hours inadvisable.
Is said to be *Habit Forming.*

Doctor's Price for
1000 Tablets Grains 5
$8.00

Cost of Each Tablet
$\frac{8}{10}$ of a Cent

NO. 10.

There are many other "Barbitals" which may be substituted for Barbital Sodium:

PENTOBARBITAL SODIUM (Abbott) N.N.R.
NEONAL (Abbott) N.N.R.
PHENOBARBITAL SODIUM, N.N.R.
(Luminal-Sodium)
(Luminal Soluble)
IPRAL (Squibb) N.N.R.
SODIUM AMYTAL (Lilly) N.N.R.

"Several of the derivatives of barbital are more actively hypnotic than the parent substance and may be preferred, especially as a sedative; but there is no satisfactory evidence that the margin between the therapeutic and toxic doses of these derivatives is wider than in the cases of barbital itself." N.N.R. 1933.

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*PENTOBARBITAL*

Doctor's Price for
1000 Capsules Grains $1\frac{1}{2}$
$36.00
Cost of each Capsule
3.6 Cents

*NEONAL*

Doctor's Price for
1000 Tablets Grains $1\frac{1}{2}$
$17.20
Cost of each Tablet
1.7 Cents

NO. 11.

Where quiescence or sleep is not inducted or maintained by Barbital Sodium

*CODEINE SULPHATE*, U.S.P.
grains ¼ may be added to each dose.

℞ Mr. John Jones
255 W. 21st St.

Sodii Barbitalis 3 ss

Codeinae Sulphatis gr. $\dot{j}$ss

M. Ft. Cap. $\overline{\dot{V}J}$

Sig. Take one (or two) before retiring.

Reg. No. 1895

James Smith, D.D.S.
14 W. 39th St.

NO. 12.

In those infrequent cases where the Hypnotic agents will not do the work, the Narcotic drugs may be given.

*MORPHINE SULPHATE*, U.S.P.
Grains ⅛ to ¼

or

*CODEINE SULPHATE*, U.S.P.
Grains ½ to 1

They may be given hypodermically or by mouth.

*Habit forming*

Must be given with considerable discretion. Prescriber must have Narcotic License.

NO. 13.

It is suggested that the Dentist or Oral Surgeon may further his development of simple, official, prescribing by dispensing the various medicines himself in small plain envelopes on which are written the instructions for taking.

# BUREAU OF PUBLIC RELATIONS

## A DENTAL SURVEY OF THE SCHOOL CHILDREN OF AMERICAN SAMOA*

By R. A. FERGUSON,† D.D.S., Norfolk, Va.

DENTAL caries probably is the oldest and most nearly universal disease to which man is subject. No people seem to be exempt from its destructive influences. Careful surveys in many communities indicate it is on the increase. Because it is not a fatal disease *per se*, the laity has but a faint idea of the enormous price the human race pays in pain, nervous energy, esthetic values and interference with proper mastication of food, with consequent impairment of digestion. These are but superficial manifestations of its ravages. Given,[1] writing of dental conditions of and a dental standard for Asiatic labourers, says:

> Study of the Asiatic convinces one that such a standard is not beyond our reach; it convinces one also that the problem of dental disease might be regarded as a key problem, the solution of which would mean not only the prevention of dental disease, but of many of the diseases of digestion and nutrition that occupy such a conspicuous place in modern pathology. Dental disease in the Asiatic would appear to represent only the first stage in a trail of pathology that has already become established in Western civilization. This insidious onset of dental disease in the Asiatic would appear to be the first pathological evidence of Western influence.

In a crowded community where dental caries is well nigh universal, it is impossible to discover the causes; but in an isolated community such as American Samoa, where the disease is still localized, it should be possible to determine the causes and mode of transmission.

### ETIOLOGY

The etiology of dental caries is unknown. Every year, new theories regarding its cause are advanced and old ones discarded. About fifty years ago, Miller stated his theory of dental decay, which briefly was as follows: Starchy food became lodged between the teeth or at other places where it could not readily be removed by the brush or by the coarser food during mastication. Under these food plaques, lactic-acid-producing bacteria liberated acid which dissolved the inorganic salts of the enamel and dentin, exposing the organic matrix of the dentin, which was then destroyed by saprophytes. This theory was almost universally accepted at the time. G. V. Black, "the father of modern dentistry," was an exponent, as well as many other prominent

*The opinions or assertions contained in this article are the private opinions or assertions of the writer and are not to be construed as official or reflecting the views of the Navy Department or the Naval service at large.—Article 113, U. S. Navy Regulations.

†Lt. Commander, D.C., U. S. Navy; Member Public Health Department of American Samoa.

1. Given, D. H. C.: Health and Empire; J. Roy. Nav. M. Service, 18:187-198, 1932.

men. The whole structure was built around the idea that "a clean tooth never decays," a phrase which J. Leon Williams, the most prominent exponent of this theory, claimed to have originated. To some, this explanation did not answer satisfactorily such questions as: Why is dental decay often rampant in mouths scrupulously clean while other mouths positively filthy show no evidence of it? or: Why the increased susceptibility in pregnancy though the most rigid oral prophylaxis is practiced? These and similar unanswered pertinent questions caused the investigations to continue, and today

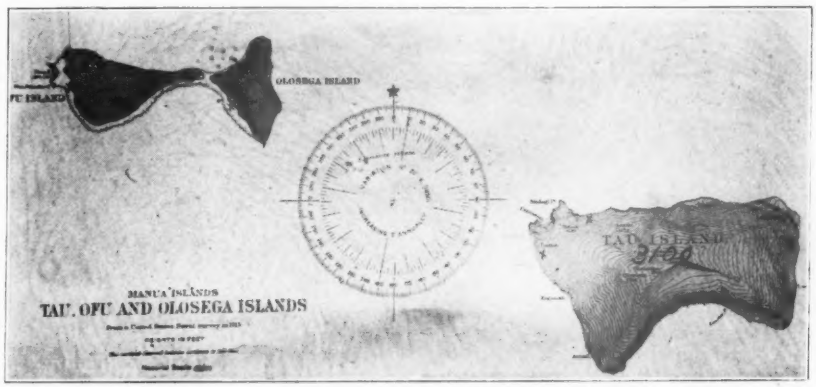



Fig. 1.—Manu'a group of islands of American Samoa.

medical opinion on this disease is in a high state of fluidity. One group of investigators believe that the primary cause of caries is a deficiency of calcium in the diet; another, a deficiency of phosphorus. There are those who consider the most important factor the resistance of the tooth itself; while others regard the neutralizing power of the saliva as the important factor. The latest theory is that which has been advanced by Corby,[2] and which he states as follows:

> Dental caries is a symptom of abnormal complex nerve reflexes, caused by a disturbed mental state altering the quantity and chemical composition of the fluids of the body. The mind acts as the agent influencing favorably or unfavorably the quantity and the chemical composition of these fluids.

The most generally accepted theory, which considers dental caries a nutritional disorder, is concisely stated by Apperman[3]: "Dental caries is really an expression of a constitutional disturbance originating in certain nutritional deficiencies." Whatever these deficiencies are, never before has this disease been the object of so much scientific research as is now being directed towards it, and I agree with Davis[4] when he says:

> Never before has hope for the discovery of the cause and control of dental caries been more bright than at the present time. The last word has yet to be spoken. Much additional research is still necessary to establish all the essential elements, but enough has been established to point unmistakably to the importance

2. Corby, A. E.: Dental Caries and Periodontoclasia: Etiology and Control, D. Cosmos, 75:676-682 (July) 1933.

3. Apperman, I.: Calcium Metabolism and Dental Caries, D. Cosmos, 74:841-852 (Sept.) 1932.

4. Davis, W. R.: Editorial, Mich. D. Soc. Bull., 43:13 (March) 1931.

**of proper nutrition. It is interesting to know that such workers as Bunting, Mellanby, McCollum, Drain, Howe and others, pursuing their own separate investigations, are coming to many similar conclusions.**

AMERICAN SAMOA

Samoa is a group of islands in the South Pacific lying from 13.5 to 14 degrees south latitude and from 168 to 173 degrees west longitude. They are distant, approximately, from San Francisco 4,160 miles; from Honolulu, 2,254 miles; from Panama, 5,737 miles; from Sidney, 2,354 miles; from Yokohama, 4,022 miles, and from Suva (Fiji), the nearest place of importance, 688 miles. Rose Island, the most eastern of the group, is of coral formation and uninhabited. The others are volcanic in origin, mountainous, covered with a dense tropical vegetation and for the most part surrounded by coral reefs. For some time previous to the year 1900, the affairs of the whole group were administered by the three great powers, Great Britain, Germany and the United States. During that year, Britain withdrew, and the islands east of the hundred seventy-first degree were assigned to the United States, the Navy Department assuming control. This eastern group, known as American Samoa, consists of Tutuila, the main island, the Manu'a group of three smaller islands, namely, Ofu, Olosega and Tau, lying 60 miles eastward of Tutuila, and several small unimportant ones. Tutuila is of irregular shape, about 18 miles long and from 5 to 6 miles wide, containing about 40.2 square miles.

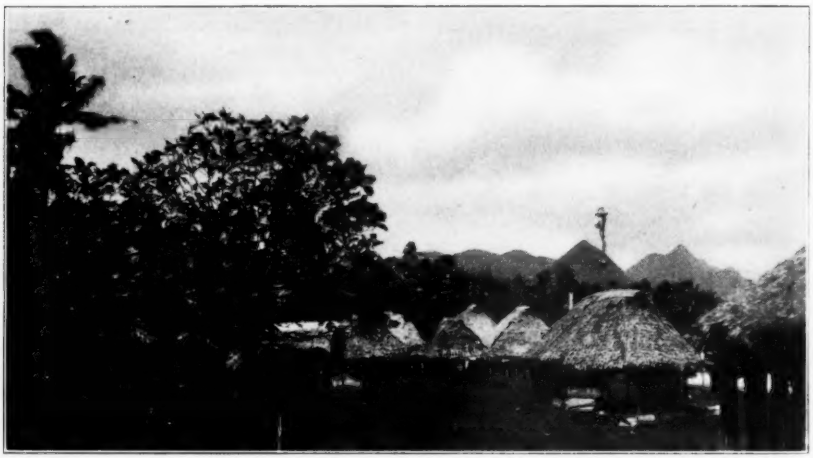


**Fig. 2.—Samoan village. The high mountain to the right is Matafoa (High Point), the highest peak of Tutuila (2,100 feet).**

The aspect is extremely rugged, a mountainous ridge from 1,000 to 2,000 feet high running almost the entire length of the island with spurs on either side and deep indentations of valleys all around. The rainfall is approximately 16.4 inches per month and the mean annual temperature is 81.75 degrees. The population in 1933 was 8,455.

The islands of the Manu'a group are similar in topography to Tutuila and

contain about 17 square miles, Tau being much the larger with a population in 1933 of 1,306, Ofu, 472, and Olosega, 459, the total population of islands being 10,692, with a public school enrollment of 2,116. The Samoans, who are true Polynesians, are a care-free, easy-going people, noted for their friendliness. They are of fine physique.

There are no civilian medical or dental practitioners in American Samoa. A careful search fails to reveal a record of any dental practitioners ever having been here, all this work being done by Navy personnel. The benefits of modern medicine came with the American occupation, and the first dental surgeon, F. L. Morey, now a commander in the Naval Dental Corps, was stationed here in 1917.

Fig. 3.—Samoan girl with her bodyguard. The headdress, called the "tapan," indicates that she is a daughter of a chief.

### DENTAL CONDITIONS

Before presenting the findings regarding the dental conditions of the school children of these islands, it is fitting to say that great difficulty has been encountered in securing and assembling data. The rugged condition of the country, the distance that it is necessary to travel, the extreme distance between schools, over 75 miles of mountain and sea, the difficulty in learning the language and the fact that there was no dental reference library were some of the obstacles to be overcome.

When I reported in Samoa, the statement was made to me that "the Samoans have the best teeth on earth." This naturally aroused my curiosity, and immediately investigations were undertaken.

The first schools visited were the Poyer, the Brothers School and the Sisters School. These three schools are directly across the harbor from the Naval Station and are of special interest since the student body is made up of children of parents whose occupations, as given below, have brought them more under

the influences of civilization than the average Samoan. The male parents are:

1. Fita Fita guard (native guard), all full blooded Samoans of highest type.
2. Naval enlisted personnel of Samoan blood as above.
3. Civil service employes, Samoans and whites, Japanese and Filipinos married to Samoan women.
4. Traders of various nationalities married to Samoan women.

The members of the first and second classes mentioned above have commissary privileges and buy large amounts of rice, flour, sugar, coffee, canned sardines and salmon, corned beef, potatoes, lard and other articles of civilized diet. The other two classes buy the same staples from the local traders. Thus, their native diet is supplemented in large part by foreign food. Also, all the children of mixed blood are in these schools and those at Leone, referred to later. It is interesting to note the apparent effect this altering of diet and miscegenation has on the dental condition of the offspring.

### POYER SCHOOL

This school, which was named for Commander J. M. Poyer, U. S. Navy, deceased, governor of American Samoa from March 1, 1915, to June 10, 1919, is the most modern school building on the islands. It has an enrollment of 341 pupils. Attendance rarely exceeds 275; but, after repeated visits, we succeeded in examining the entire enrollment. The results are shown in Table 1.

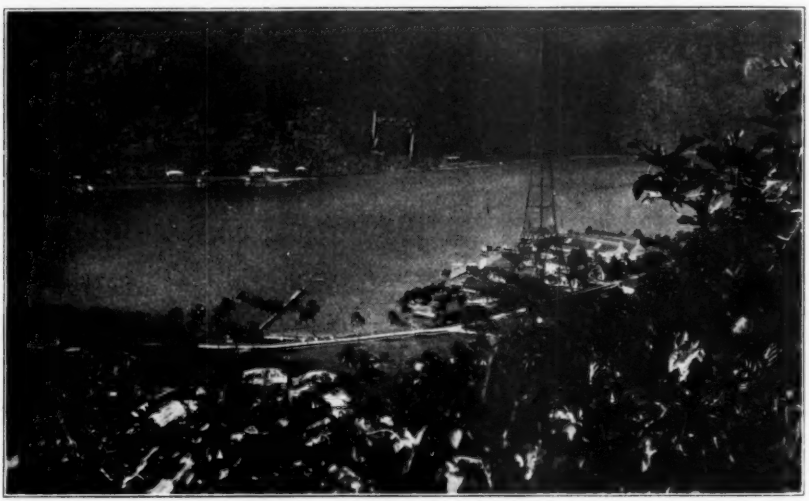


Fig. 4.—Pago Pago (pronounced Pango Pango) harbor, from mountains back of naval station. The Poyer and Brothers schools are across the bay.

There were only five males and eight females of mixed blood in this school, and as there were no cavities among the males and only eight among the females, the relatively high percentage of caries found in this school, as compared to some of the other schools, cannot be accounted for on the basis of mixed blood. Diet, the remaining possible major factor, will be discussed later.

TABLE 1.—RESULTS OF EXAMINATION AT POYER SCHOOL

| Age groups | 5–9 | 10–14 | 15–19 | 20–24 | No. Pupils Examined | No. Pupils with Cavities | Percentage Pupils with Cavities | No. Teeth Examined | No. Carious Teeth | Percentage Carious Teeth | Total Carious Teeth Per Cent |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Males | 68 | 94 | 59 | 5 | 226 | 53‡ | 23.45 | 6312 | 121 | 1.91 | 1.7 |
| Females | 50 | 56 | 9 | 0 | 115 | 23 | 20.00 | 3056 | 48 | 1.24 | |
| Totals | 118 | 150 | 68 | 5 | 341 | 76 | 22.28 | 9368 | 169 | | |

| | | 5–9 | | 10–14 | | 15–19 | | 20–24 | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities |
| Caries in Males | T* | 15 | 39 | 4 | 7 | 0 | 0 | 0 | 0 | 19 | 46 |
| | P† | 5 | 5 | 18 | 33 | 14 | 37 | 0 | 0 | 37 | 75 |
| | | | | | | | | | | 56‡ | 121 |
| Caries in Females | T* | 8 | 13 | 4 | 11 | 0 | 0 | 0 | 0 | 12 | 24 |
| | P† | 4 | 6 | 9 | 18 | 0 | 0 | 0 | 0 | 13 | 24 |
| | | | | | | | | | | 25 | 48 |

*Temporary teeth.
†Permanent teeth.
‡This apparent discrepancy is explained by the fact that three of the pupils had cavities in both temporary and permanent teeth. The foregoing explanation applies to this and other tables where indicated.

TABLE 2.—FINDINGS IN BROTHERS AND SISTERS SCHOOLS

| Age groups | 5–7 | 10–14 | 15–19 | No. Pupils Examined | No. Pupils with Cavities | Percentage Pupils with Cavities | No. Teeth Examined | No. Carious Teeth | Percentage Carious Teeth | Total Carious Teeth Per Cent |
|---|---|---|---|---|---|---|---|---|---|---|
| Males | 29 | 69 | 22 | 120 | 49 | 40.83 | 2304 | 99 | 4.29 | 4.84 |
| Females | 15 | 20 | 6 | 41 | 17 | 41.46 | 872 | 55 | 6.3 | |
| Totals | 44 | 89 | 28 | 161 | 66 | 41.00 | 3176 | 154 | | |

| | | 5–7 | | 10–14 | | 15–19 | | Total | |
|---|---|---|---|---|---|---|---|---|---|
| | | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities |
| Caries in Males | T | 11 | 36 | 4 | 6 | 0 | 0 | 15 | 42 |
| | P | 5 | 13 | 26 | 40 | 4 | 4 | 35 | 57 |
| | | | | | | | | 50 | 99 |
| Caries in Females | T | 4 | 12 | 0 | 0 | 0 | 0 | 4 | 12 |
| | P | 7 | 11 | 9 | 30 | 2 | 2 | 18 | 43 |
| | | | | | | | | 22 | 55 |

TABLE 3.—FINDINGS IN LEONE MALE AND FEMALE SCHOOLS

| Age groups | | 5–9 | | 10–14 | | 15–19 | | No. Pupils Examined | No. Pupils with Cavities | Percentage Pupils with Cavities | No. Teeth Examined | No. Carious Teeth | Percentage Carious Teeth | Total Carious Teeth Per Cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males | | 78 | | 92 | | 51 | | 221 | 24 | 10.86 | 5098 | 39 | 0.76 | 0.83 |
| Females | | 55 | | 80 | | 43 | | 178 | 14 | 7.86 | 4936 | 44 | 0.89 | |
| Totals | | 133 | | 172 | | 94 | | 399 | 38 | 9.52 | 10034 | 83 | | |
| | | | | | | | | Total | | | | | | |
| | | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities | | | | | |
| Caries in Males | T | 6 | 12 | 1 | 2 | 0 | 0 | 7 | 14 | | | | | |
| | P | 5 | 6 | 9 | 11 | 4 | 8 | 18 | 25 | | | | | |
| | | | | | | | | 25 | 39 | | | | | |
| Caries in Females | T | 4 | 17 | 5 | 11 | 0 | 0 | 9 | 28 | | | | | |
| | P | 0 | 0 | 3 | 4 | 3 | 12 | 6 | 16 | | | | | |
| | | | | | | | | 15 | 44 | | | | | |

TABLE 4.—RESULTS IN EXAMINATIONS IN SMALL "JUNGLE" SCHOOLS

| Age groups | | 5–9 | | 10–14 | | 15–19 | | No. Pupils Examined | No. Pupils with Cavities | Percentage Pupils with Cavities | No. Teeth Examined | No. Carious Teeth | Percentage Carious Teeth | Total Carious Teeth Per Cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males | | 241 | | 165 | | 57 | | 463 | 14 | 3.02 | 12228 | 24 | 0.196 | 0.193 |
| Females | | 186 | | 128 | | 30 | | 344 | 12 | 3.49 | 8988 | 18 | 0.2 | |
| Totals | | 427 | | 295 | | 87 | | 807 | 26 | 3.22 | 21216 | 42 | | |
| | | | | | | | | Total | | | | | | |
| | | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities | | | | | |
| Caries in Males | T | 4 | 8 | 0 | 0 | 0 | 0 | 4 | 8 | | | | | |
| | P | 2 | 6 | 4 | 4 | 4 | 6 | 10 | 16 | | | | | |
| | | | | | | | | 14 | 24 | | | | | |
| Caries in Females | T | 8 | 10 | 2 | 5 | 0 | 0 | 10 | 15 | | | | | |
| | P | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 3 | | | | | |
| | | | | | | | | 12 | 18 | | | | | |

Table 2 records the findings in the Brothers and Sisters schools.

The pupils in these two schools, which have been tabulated together, have come more under foreign influences than have any other children in these islands. Their

diet is more nearly papalagi[5] (white-man's), and there is a greater infusion of foreign blood. Of the seventy-two having cavities, fifty-four were of mixed blood and had 130 of the 154 cavities noted. The Japanese-Samoans were the chief sufferers. Thirty-four of the fifty-four cavities in the temporary teeth were seen in ten Japanese-Samoans and thirty-five of the 100 cavities in the permanent teeth were in the mouths of nine children of the above-mentioned nationality.

These schools are 12.6 miles from the naval station and connected by bus over a most tortuous and rough mountain road. Therefore, it would be expected that foreign influences of diet and miscegenation would be less important than in the schools around the naval station. A glance at Table 3 confirms this conclusion, by both the greatly reduced percentage of pupils with caries and the percentage of carious teeth.

Leone is the most important village

TABLE 5.—RESULTS OF OBSERVATIONS IN MANU'A SCHOOLS

| Age groups | | 5–9 | | 10–14 | | 15–19 | | No. Pupils Examined | No. Pupils with Cavities | Percentage Pupils with Cavities | No. Teeth Examined | No. Carious Teeth | Percentage Carious Teeth | Total Carious Teeth Per Cent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Males | | 147 | | 137 | | 36 | | 320 | 15 | 4.7 | 8516 | 26 | 0.305 | 0.295 |
| Females | | 87 | | 116 | | 26 | | 229 | 8 | 3.5 | 6168 | 17 | 0.274 | |
| Totals | | 234 | | 253 | | 62 | | 549 | 23 | 4.19 | 14684 | 43 | | |
| | | Pupils | Cavities | Pupils | Cavities | Pupils | Cavities | Total Pupils | Total Cavities | | | | | |
| Caries in Males | T | 8 | 14 | 0 | 0 | 0 | 0 | 8 | 14 | | | | | |
| | P | 3 | 4 | 2 | 4 | 3 | 4 | 8 | 12 | | | | | |
| | | | | | | | | 16 | 26 | | | | | |
| Caries in Females | T | 2 | 4 | 0 | 0 | 0 | 0 | 2 | 4 | | | | | |
| | P | 1 | 2 | 4 | 9 | 1 | 2 | 6 | 13 | | | | | |
| | | | | | | | | 8 | 17 | | | | | |

The Filipino-Samoan came next. Two 12-year-old sisters, twins, identical in appearance even to the number of teeth affected and surfaces involved, presented five cavities each. The remainder of the 130 cavities mentioned were found among a mixture of Samoans with white, Japanese, Filipino and Chinese strains.

Table 3 presents the findings in the Leone Male and Female schools.

away from the station, boasting a missionary school and hotel among other civilized institutions. There is a very limited amount of papalagi food eaten, and the few pupils of mixed blood enrolled in school furnished their full quota of tooth decay. Among the males, there were eight of mixed blood with thirteen cavities, and among the females, sixteen with thirty-four cavities, a total of twenty-four pupils and forty-seven cavities, a rather large percentage. These pupils of

5. Pronounced pa-lang-i.

TABLE 6.—TOTALS DERIVED FROM ALL EXAMINATIONS

| | MALES | | | | | | | | | FEMALES | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Temp. Teeth | | Perm. Teeth | | | | | | | Temp. Teeth | | Perm. Teeth | | | | | |
| Age | Pupils Examined | No. with Cavities | Cavities | No. with Cavities | Cavities | Gingivitis | Calculus | Stain | Malocclusion | No. Pupils Examined | No. with Cavities | Cavities | No. with Cavities | Cavities | Gingivitis | Calculus | Stain | Malocclusion |
| 5 | 67 | 2 | 6 | .... | .... | .... | 3 | 13 | .... | 72 | 3 | 7 | .... | .... | .... | 6 | 27 | 1 |
| 6 | 124 | 17 | 45 | .... | .... | 2 | 17 | 53 | 2 | 66 | 3 | 5 | .... | .... | 1 | 3 | 4 | .... |
| 7 | 124 | 9 | 19 | 1 | 2 | .... | 22 | 44 | .... | 82 | 10 | 27 | 1 | 2 | .... | 13 | 20 | 1 |
| 8 | 115 | 7 | 26 | 8 | 13 | 2 | 26 | 44 | .... | 85 | 3 | 7 | 6 | 10 | 3 | 9 | 15 | .... |
| 9 | 133 | 9 | 13 | 11 | 19 | .... | 26 | 57 | 5 | 88 | 7 | 10 | 5 | 7 | 1 | 18 | 29 | 2 |
| 10 | 158 | 9 | 15 | 16 | 22 | 14 | 41 | 79 | 3 | 123 | 2 | 4 | 6 | 15 | 3 | 17 | 50 | .... |
| 11 | 93 | .... | .... | 12 | 18 | 3 | 10 | 33 | 1 | 69 | 5 | 13 | 5 | 13 | 1 | 9 | 20 | 1 |
| 12 | 126 | .... | .... | 13 | 21 | 9 | 33 | 55 | 1 | 87 | 2 | 6 | 10 | 20 | 1 | 17 | 37 | .... |
| 13 | 102 | .... | .... | 8 | 10 | 3 | 18 | 31 | 1 | 65 | 2 | 4 | 2 | 6 | .... | 5 | 17 | 1 |
| 14 | 78 | .... | .... | 10 | 21 | 8 | 25 | 39 | 2 | 56 | .... | .... | 3 | 8 | 1 | 5 | 18 | 2 |
| 15 | 74 | .... | .... | 10 | 18 | .... | 22 | 28 | 2 | 63 | .... | .... | 2 | 6 | .... | 7 | 19 | .... |
| 16 | 55 | .... | .... | 7 | 15 | 4 | 20 | 18 | 1 | 23 | .... | .... | 3 | 8 | .... | 2 | 5 | .... |
| 17 | 42 | .... | .... | 5 | 9 | 6 | 19 | 20 | .... | 11 | .... | .... | 1 | 2 | .... | 1 | 4 | .... |
| 18 | 33 | .... | .... | 5 | 11 | 9 | 14 | 17 | .... | 12 | .... | .... | 1 | 2 | .... | .... | .... | .... |
| 19 | 21 | .... | .... | 2 | 6 | 2 | 6 | 7 | .... | 5 | .... | .... | .... | .... | .... | .... | .... | .... |
| 20 | 5 | .... | .... | .... | .... | 2 | 5 | 5 | .... | .... | .... | .... | .... | .... | .... | .... | .... | .... |
| | 1,350 | 53 | 124 | 108 | 185 | 64 | 307 | 543 | 18 | 907 | 37 | 83 | 45 | 99 | 11 | 112 | 265 | 8 |

TABLE 7.—INCIDENCE OF CARIES

| Right | Upper Arch | | | | | | | | | | | | | | | Left |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Third Molar | Second Molar | First Molar | Second Bicuspid | First Bicuspid | Cuspid | Lateral Incisor | Central Incisor | Central Incisor | Lateral Incisor | Cuspid | First Bicuspid | Second Bicuspid | First Molar | Second Molar | Third Molar |
| Permanent teeth | 2 | 8 | 21 | 9 | 3 | 2 | 8 | 6 | 8 | 8 | 4 | 8 | 4 | 27 | 20 | 6 |
| Temporary teeth | .... | 21 | 19 | .... | .... | 3 | 1 | 3 | 4 | 1 | 2 | .... | .... | 13 | 20 | .... |
| | Lower Arch | | | | | | | | | | | | | | | |
| Permanent teeth | 8 | 3 | 28 | 8 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 9 | 4 | 37 | 31 | 3 |
| Temporary teeth | .... | 29 | 27 | .... | .... | 3 | 3 | 3 | 1 | 0 | 6 | .... | .... | 26 | 22 | .... |

mixed blood were practically all of White-Samoan extraction.

Table 4 presents a much more pleasing picture. It gives the result of investigations in eighteen small "Jungle" schools. These people are absolutely unaffected by outside influences, being strictly Samoan in diet, customs and lineage. These schools are located on the beach and form a fringe around the entire island of Tutuila. As the conditions were identical, the data have been assembled in one table.

OTHER CONDITIONS NOTED

Although the primary investigations were made to determine the incidence of dental caries among the school children, certain other conditions were noted, as follows:

*Stain.*—There were 543 cases of stain among the males and 265 among the females, a total of 808 cases. The stain was rather heavy, with a somewhat rough appearance and of a yellowish green, very similar in color to chlorine gas. It is said to be caused by the chewing of sugar cane and a gum exudate from the breadfruit tree. More pronounced among the pupils in the "Jungle" schools, it is of importance since the roughened surface seemed conducive to the accumulation of calculus.

Fig. 5.—Samoan school children and school buildings.

Table 5 presents the results of observations in the Manu'a group of islands. As the data were practically identical for the three islands, they have been compiled in one table. There are no pupils of mixed blood and papalagi food is not used, everything being strictly Samoan.

Table 6 gives the totals from all examinations.

Table 7 has been arranged according to incidence of dental caries in the various teeth.

*Calculus.*—There were 419 cases of calculus noted, 307 among the males and 112 among the females. In no case were the deposits heavy, many cases being so light that they could easily be removed by a toothbrush. These deposits set up a mild localized gingivitis in many cases,

sixty-four among the males and eleven among the females, which would undoubtedly clear up after scaling.

*Malocclusion.*—There were eighteen cases of malocclusion noted among the males and eight among the females. These were very mild cases, classified as Class 1 (Angle), a normal mesiodistal relation of the posterior teeth with slight irregularities of one or more anterior teeth. Most cases promised to correct themselves in time. No case of prognathism was noted.

There was no evidence of adenoids.

Fig. 6.—Samoan school. No desks or seats are used, the children sitting on mats spread over clean coral fragments. No nails are used in the construction of the building, the frames being bound together by cords.

Arches varied slightly, but could be classified as normal. No pulpless teeth nor periapical disease was noted. There were twenty-seven fillings which were classed as caries, and three teeth were lost from extraction or accident.

### DENTAL CONDITIONS AMONG OLDER SAMOANS

As an index of dental caries among the adult male full-blooded Samoans, a random selection of fifty men from the Fita Fita guard was made. For comparative purposes, a like selection was made from the white enlisted men on duty at the local naval station.

*Results of Examination.*—Samoans examined were of an average age of 30 years and 3 months. Fillings numbered 81, extractions, 48. Americans were of an average age of 33 years and 8 months. Fillings numbered 259; extractions, 191. Listing fillings and extractions under caries, as it is assumed the primary cause for both was caries, the Samoans show an average of two and six-tenths defective teeth per man from caries against an average of seven defective teeth per man for the Americans. It should be remembered that these are picked men, dentally as well as otherwise. Recruiting statistics for 1932 showed that 12,811 applicants for enlistment were rejected that year for dental defects alone. Another fact to be considered is that these Samoans have been consuming the regular Navy ration for an average of nine years each.

As to the older Samoans, we have yet to see a Samoan over 35 years of age who has not suffered from some form of gum trouble. Periodontoclasia is well nigh universal, being present in 98 cases out of 100 examined. The possible reasons for this are: (1) total lack of oral hygiene, the Samoan having never made the acquaintance of the toothbrush; (2) excessive accumulation of calculus throughout a lifetime, and (3) excessive use of strong native tobacco. Tobacco, being a vasoconstrictor, lessens the supply of blood to the soft tissues of the mouth. Gum resorption, which reaches the maximum in these cases, is followed by an unusual type of caries. While the crown remains free from defects, decay sets in at the gingival margin and proceeds through the tooth, severing the crown from the roots. At first, there is little evidence of decay, but rather a softening process, the softened material often remaining in place until the pulp in the root canals is exposed. This decay is found on the buccal surface of the lower bicuspids and molars only, and, with the exception of periodontoclasia, is the major cause for extraction—about the only dental treatment requested or desired by elderly Samoans.

**Fig. 7.—Samoan family. There is no furniture. The family sit on mats spread on the crushed coral floor. Sleeping mats are rolled and placed on beams overhead.**

COMMENT

In the accompanying tables, there are several factors which invite attention. It is very evident that the Samoan is remarkably free from dental caries if left in his native environment and his susceptibility is markedly increased in the presence of altered diet and miscegenation. In the Poyer School (Table 1), as the thirteen children of mixed blood contributed eight cavities, we may disregard miscegenation as of no import in the relatively high percentage of dental caries as compared to the percentage shown in the

"Jungle" schools. There is only one other important factor to be considered, diet. It is a well known fact that the Samoan is fond of the white man's food. If finances permit, he will buy a large amount of the staples of civilized diet. As has been stated before, many of the pupils of Poyer School are the children of members of the Fita Fita Guard and naval enlisted (Samoan) personnel. These men receive the same pay as the corresponding ratings in the Navy and Marine Corps. The problem of rent, heat and electric light does not exist for them, and cost of clothing is negligible. It is evident that they are in a far more comfortable financial status than men in the same enlisted ratings in the United States. They are gluttonous eaters. This higher economic status enables them to buy large quantities of food, some families using as much as 100 pounds of rice a month. They are particularly fond of candies, sirups, jams, marmalades and chewing gum. This deviation from their simple coarse native diet with a total disregard of oral hygiene may readily account for the increased susceptibility to tooth decay.

What has been said about the Poyer School in regard to diet may be said with equal truth about the Brothers and Sisters schools, the student body being derived from the type of natives previously enumerated in four classes. The second factor of mixed blood enters very strongly into consideration in these schools. Of the 161 pupils examined in the Brothers and Sisters schools, the fifty-four, or 33.5 per cent, of mixed blood, furnished 130, or 84.4 per cent, of the 154 cavities noted. In the Leone School, the only other school having pupils of mixed blood, these numbered twenty-four or 6 per cent of the pupils examined, and supplied 47 or 56.63 per cent of the eighty-three cavities noted.

To recapitulate: In the Poyer School,

**Fig. 8.—Looking across the bay from the naval station. A new 26,000 Matson liner lies at anchor. The Poyer School can be seen at its bow, the Brothers School at the stern.**

we had only the dietetic factor as a major problem and the percentage of carious teeth was 1.8; while in the Brothers and Sisters schools we had the dietetic and mixed blood factors operative, and the percentage increased to 4.84. In the Leone schools, where the food factor was practically negligible and the factor of mixed blood of much less importance, the percentage of caries dropped to 0.83; while in neither of the strictly Samoan schools did these two factors enter in, and the percentage fell to 0.193 and 0.293, respectively, in these schools.

Fig. 9.—Samoan village. The ruined building in the center was the church, destroyed by a hurricane. When this happens, the church is not rebuilt, but an entire new edifice is reared elsewhere. The Samoans say, "If God approved of the church, he would not allow it to be destroyed."

The total enrollment of 2,116 pupils in the public schools of American Samoa were examined. In addition, in two small missionary schools, the pupils were examined. This gave a total of 2,257 children examined. Of this number, 229, or 10.14 per cent, had one or more carious teeth and presented 491 cavities. Males examined numbered 1,350, or 59.82 per cent of the total enrollment. Of this number, 155, or 11.48 per cent, presented 309 cavities, or 62.93 per cent of total cavities. Females numbered 907, or 40.18 per cent of the total enrollment. Seventy-four, or 8.15 per cent, presented 182 cavities, or 37.07 per cent of the total cavities noted. The total number of teeth examined was 58,478, of which 491, or 0.84 per cent, were carious. The percentage of carious teeth among those presenting cavities was 2.14 teeth per pupil.

It is believed that the accompanying tables show one of the lowest incidence

of caries ever reported. The nearest approach of which a record is available was reported by Bee,[6] in a general inspection of the inhabitants and island of Tristan Da Cunha, one of the Tristan group situated 1,500 miles from Capetown, half way across to Buenos Aires. Bee states:

> The island was first occupied during the captivity of Napoleon at St. Helena; garrisons were established at Ascention and Tristan Da Cunha in case these lonely islands might be used as bases for his release. When the garrison was evacuated, one, Corporal Glass, elected to remain with one or two others and was allowed to do so. After a few years, these men asked the captain of a passing merchant vessel to bring them women from St. Helena to act as wives, and this the kindly captain accordingly did on his next visit, though what reward or reimbursement he could have received for doing so is not known. This is the origin of the present Community.

There were 163 people on the island at the time of the inspection, January, 1932. There were seventy-eight persons between the ages of 1 and 21 years, with but a single carious tooth. The percentages of carious teeth among the permanent teeth of the adults were as follows: age 22-32, 0.504; age 33-45, 2.61; age 46-55, 11.8; 56 years and over, 7.46 per cent. Incidentally, one man in the latter group was 75 years old and had perfect teeth. Another notation was 130 perfect mouths.

Naturally, we are interested in the diet of these islanders. Bee[6] gives it as follows:

> Flesh Food.—Fish is the main article in this category, and is their staple food. In the winter they occasionally have beef or mutton, but it is a luxury. Cereals.—No wheat is grown on the island. They never have any bread or flour unless a ship happens to call. (One year has elapsed since the last ship called.) Potatoes.—These form, together with fish, the staple food. Milk.—Plentiful and is used freely. Eggs.—Hen's eggs and penguin's eggs form a fair proportion of their diet. Sugar.—Hardly ever used; they can get it only from ships. Green vegetables.—Some cabbages, turnips, etc., are grown and used while they last. Salt is scarce; they make it by evaporating sea water. They have no condiments. Tea, coffee, and cocoa are obtained from ships and used sparingly. Alcohol is never used. From the foregoing list it will be seen that the staple diet is fish and potatoes; the other articles being in the nature of luxuries. Therefore, the diet is rich in carbohydrates and phosphates.

Bee[6] calls attention to the fact that the islanders are all breast-fed in infancy and that they never clean their teeth. He also calls attention to the large proportion of carbohydrates in their diet. Our interest in the diet of these islanders concerns its comparison with the native Samoan diet.

The mainstay of the native Samoan diet is banana and taro. Poi is not eaten in Samoa. Taro is an araceous plant cultivated throughout the tropics for its edible starchy tuberous rootstock. Next in importance are cocoanuts, breadfruit, avocados and papayas, the three latter in season. Also a certain amount of native oranges, limes and mangoes are eaten, but these are regarded more as luxuries. Flesh foods are pig, chicken and fish, which are scarce and regarded as luxuries, pig and chicken being eaten on special occasions. The waters around the islands abound in food fish, but the Samoan is an inefficient fisherman. At low tide, the reef swarms with men, women and children seeking among the coral growths and seaweeds for small fish, shellfish, the octopus, certain seaweed and sea urchins, which are usually eaten on the spot. Rarely beef, horse or dog is eaten. In lieu of sugar, huge stalks of sugar cane are chewed. Salt is rarely used, but certain articles of diet are boiled in sea water. The diet, therefore, is rich in carbohydrates and, to a lesser extent, phosphates. It also contains a small amount of protein. All the children are breast-fed in infancy, but the weaning

6. Bee, A. G.: Visit of H. M. S. Carlisle, January, 1932, J. Roy. Nav. M. Service, 18:173-187, 1932.

process begins about the sixth month (information from many native sources), when a diet of banana soup and a small native banana are substituted as quickly as possible for mother's milk. To this is added the grated fruit of young cocoanuts. There is a total lack of oral hygiene.

Jones, Larsen and Prichard[7] report appalling dental conditions among the school children of the Hawaiian islands, especially among the Japanese-Hawaiians. It is worthy of note that this same racial stock was the most vulnerable to dental disease among the mixed blood Samoans. As a side light on the foregoing conditions, an interesting case came under observation recently. A Samoan girl, aged 21 years, reported for treatment. This woman had recently returned from Honolulu, where she had resided for the past four and one-half years. When she left Samoa, her teeth were perfect. While living in Hawaii, twenty-two cavities developed, which were filled. It was necessary to fill two more cavities for this patient. Her diet for the time mentioned was that consumed by the lower class, mostly poi, rice, yams and sweet potatoes. She had enjoyed good health while in Honolulu.

Weston A. Price of Cleveland has arranged to make an analysis of specimens of saliva which will be provided. Dr. Price will undoubtedly make an independent report of his findings.

Given[1] reminds us:

> In conclusion, with a subject of such world-wide importance as dental disease, no field of inquiry should be left unexplored. It seems to me that the hitherto unexplored outposts of civilization offer the highest possibilities for the solution of the tangible causes underlying dental caries and the means of preventing it.

In this connection, the program of the Public Health Department of American Samoa contemplates further studies along this line, which will, of course, be published.

CONCLUSIONS

1. The Samoans possess a high degree of immunity to dental caries as compared to more highly civilized people.

2. Some influences of civilization seem to be destroying or reducing this immunity in the younger generation. The most important of these influences appear to be diet and miscegenation.

3. Further investigations should be made in this most interesting outpost of civilization.

7. Jones, Martha R.; Larsen, N. P., and Prichard, G. P.: Dental Disease in Hawaii, D. Cosmos, 72:439 (May), 574 (June), 685 (July), 797 (Aug.) 1930.

## THE DENTAL HYGIENIST PAYS DIVIDENDS

By HARRIET FITZGERALD, Berkeley, Calif.

THE present era through which organized dentistry is passing is one which concerns all dentists and dental hygienists. Whether we are engaged in private practice or public institutions, we are dependent on the public for our income.

Does the public want our service? That the public needs our service is an undeniable truth. Unfortunately, the public as yet is not aware of the dental hygienist's ability to serve. Likewise, many members of the dental profession are not cognizant of her ability. Were

dentists, as a whole, more conscious of her value in terms of increased income, more dental hygienists would be employed in public institutions.

Most dentists are convinced that the dental hygienist renders a valuable service. A few still feel that her activities infringe on their domain. The dental hygienist can be the greatest asset which the dental profession has today if she is given an opportunity. Who is better trained than she to disseminate the knowledge which the dental profession has acquired through years of study and research? Advertising agencies have tried and have succeeded in making the public more interested in mouth health. Has it been to the advantage of organized dentistry? In part; but the advertising dentists have profited most by these methods. The dental hygienists, organized under a code of ethics like that of the American Dental Association, stand ready to educate the American public.

Dentistry is responsible for the creation of this field of public health service. Those men who founded our profession realized the importance of dental hygiene, and realizing it, they had the power of conveying it to others. School departments, state health departments and public institutions employed dental hygienists, but there were too few of these dentists who heard the crying need of the masses. Consequently, dental hygiene has not occupied its rightful place with the allied branches of public health. Today, almost twenty years after the birth of dental hygiene, thousands of public school systems and millions of people are ignorant of the service which the dental hygienist renders.

Why is this so? Human wills determine human actions. Dentistry has been willing to take the gallery seats, while medicine has occupied the loges.

We have seen dental programs cut and eliminated in recent years. Why? Because public officials know that dentistry offers the least resistance. It has never occupied its rightful place and never will until organized dentistry educates the public. Regardless of all this, the medical profession admits that dental defects are the most prevalent of all diseases among school children.

How can we remedy this and bring dividends to all? The answer is simple. Dental hygienists should be employed in every community and should be teachers of dental health education in the schools. This is perhaps more easily said than done, but experience has proved to me that most public officials are interested in preventive dental programs if they are in accord with educational practices. Who can best present dental hygiene to school officials or directors? The dentist engaged in private practice; and herein lies his opportunity for public health service. Every important state, county or city official—be he governor, university president, or superintendent of schools—has to fall a victim of the dentist sometime during his career. At this time, he becomes not the all powerful man that you have known him to be, but the humble human being who knows fear and pain. Yours is an opportunity to serve him efficiently and also to drop just a word of sympathy, as to how you, too, have suffered because dental science was not developed when you were young. Then you can relate what cities and school departments are doing to teach the children the importance of care of the teeth—how most dental ills can be prevented if discovered in early life, and how dental programs should aim to prevent rather than to correct existing conditions. The official may begin to realize that his city is not up to other cities and he may take action. If not, you at least have given him food for thought. If you

are firmly convinced of the part dentistry plays in health, you will have no trouble convincing him, for enthusiasm is contagious.

Dental programs should be founded on the altruistic motive that humanity will be benefited. The health of the child is the cardinal principle in education, and we know that health is impossible without dentistry's contribution. A program based on the idea that it will bring more work to the dentists is bound to result in failure. But how does the dental hygienist pay dividends? The value of dividends in health to children cannot be estimated, but the dividends to the dentists are more tangible. An illustration proves this: In Berkeley, California, the dental hygiene program has been in existence since 1925. The number of children with good teeth in 1925 was 18 per cent: it now is 66 per cent. There were about fifty dentists in Berkeley in 1925: now there are ninety-seven. The population has increased only 10,000 during this time, but the ratio of dentists has more than kept pace with the population.

The dental hygiene program in Berkeley is one which is directly educational. No prophylactic work has been done owing to a legal interpretation of the school law. The dental hygienists examine the children's teeth, notify parents of defects and hold conferences with parents. In addition to this regular lesson, plans regarding all phases of dental hygiene are given by the dental hygienists. These plans have been carefully worked out so that age levels are considered. The plan has not been one of "indoctrination," but rather one of presenting facts, and children have had dental defects corrected not because they were told but because they were educated and were convinced of the importance of good teeth.

During the spring of 1933, after the dental hygienists had examined the children and notified the parents of the existing dental defects, in the short period of three months 855 children went to their dentists and had all existing defects corrected. Only one eighth of these were treated by the clinic dentists, the remaining corrections being made by the family dentists. There were 185 dentists who made the corrections and signed slips certifying that all dental work was completed. Of this number, seventy were Berkeley dentists and there are ninety-seven dentists listed in Berkeley. Thus we see that each dentist receives a dividend. The greatest dividends which the Berkeley dentists have received is the feeling that they have aided in the health and well-being of children, for that was their motive when they persuaded the Berkeley Board of Education to employ dental hygienists.

### C.W.S. DENTAL PROJECT IN OMAHA

About 2,000 Omaha school children, mostly from the third and fourth grades, will have all needed dental work completed. Three dentists, six nurses, three dental assistants and two laundresses make up the personnel. The project is under the supervision of the superintendent of health of the Omaha Board of Education, assisted by the Omaha District Dental Society. The work is being done in the four-chair dental dispensary, located in the city hall, in addition to the work of the one full time man on regular duty. Only the children of those who are entitled to relief are accepted.

### OSLO BANS SWEETS FOR CHILDREN

W. H. G. Logan, of Chicago, is in receipt of the following communication from Prof. Viggo Andresen, Oslo, Norway:

"Oslo, Octbr. 1933.

"In 1931, our honorable member of the Committee on Hygiene, Johan Brun, first director of the school dental clinic in Oslo, submitted a proposal that school children should be forbidden to take sweets and eat them within the school precincts.

"This proposal aroused unexpected resistance from certain political quarters. The present scarcity of money has perhaps been contributory to a fresh proposal, on this occasion

put forward by the chairman of the School Hygiene Committee, Arthur Collett, M.D., and having won the approval of the school board, it has been passed.

"Following is the text of the resolution:

"'Pupils attending the municipal school are forbidden to take or eat sweets within the precincts of the school.'

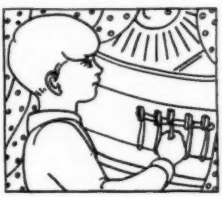
"The undersigned considers it opportune to distribute this epoch-making resolution throughout the world. This resolution, which should serve as an example to be copied elsewhere, inaugurates a new era in child-hygiene, which the Hygiene Committee of the F.D.I. must consider it their bounden duty to promote."

## FIRST GRADE DENTAL EDUCATIONAL LEAFLETS

GO TO THE DENTIST AT LEAST TWICE A YEAR

The dentist is my friend.
He helps me to have nice teeth.
I go to see him often.
Sometimes teeth have little holes in them.
If there are little holes in my teeth
the dentist will fill them.
He will help me to keep my teeth clean.

BRUSH YOUR TEETH TWICE A DAY

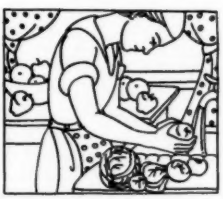


Here are our tooth brushes.
They are hanging in the sun.
The brushes are all small.
They have pretty colored handles.
The one with the yellow handle belongs to my mother.
The one with the green handle belongs to my father.
The one with the blue handle belongs to my sister.
The one with the red handle belongs to me.
I brush my teeth every night.
I brush my teeth very morning.

TOOTH BUILDING FOODS

Milk helps to build strong teeth.
Dark bread helps to build strong teeth.
Dark cooked cereals are good foods to build teeth.
I eat cereal and milk for my breakfast.
I sometimes have toast for my breakfast.
My teeth need milk and cereals.

TOOTH BUILDING FOODS



I will color the cabbage green.
I will color the oranges.
I will make the apples red.
I will color the spinach green.
I will color the tomatoes red.
Fruits and vegetables help to build strong teeth.

CHEW FOOD WELL

I run and play to make my muscles strong.
Exercise makes strong muscles.
I chew crisp foods to make my teeth strong.
Exercise makes strong teeth.
Crisp toast and crusts are good foods
to exercise teeth.
Celery and apples are crisp foods to exercise teeth.
My teeth need exercise.

NO CANDY BETWEEN MEALS

Candy and sweet foods do not build teeth.
I eat candy or cake or pudding after my meal.
First I eat the foods that build my teeth.
Then I eat sweet foods.
I sometimes eat candy and sweet foods
after I have eaten foods that build my teeth.
Candy does not help to build teeth.

This new series of six leaflets designed for first grade dental education is now ready for distribution. Each lesson is printed on 8 by 11 inch drawing paper. The wording is fitted to first grade vocabulary. The text is scientifically correct. The drawings are simple and artistic. After each lesson is learned, the drawings are to be colored by the child. This material will enable educators to coordinate the teaching of dental health with that of art and reading.

*Special notice* to mouth hygiene chairmen and others interested in dental health for children: Advise your boards of education that this inexpensive material is now available.

One set of six leaflets, including postage, 5 cents.

Twenty-five sets of leaflets, including postage, 50 cents.

# *President's Message*

## *Go Forward with the American Dental Association!*

No group can stand still in this constantly changing world. It is a case of going either forward or backward. Dentistry must go forward and will go forward if the individual dentist will support the organized effort for its advancement.

No one is going to do anything for dentistry but the dentists themselves—but with the proper support and coordination they can carry dentistry forward and to greater heights.

Remember that your membership in your local dental society is strengthening its influence in your local community, and in proportion as your local society adds strength to the American Dental Association, the American Dental Association is enabled to exert greater national influence in all health problems.

Your consistent support of the "Beneficial Circle" plan will help greatly.

A. C. Whitney.

# NEWS

## CALIFORNIA

*State to Publish Official Organ:* The Southern California State Dental Association announces that "henceforth, with the beginning of January, 1934, our Association will continue the publication of the *Journal of Southern California State Dental Association* as our own official organ."

*Joint Meeting:* A joint meeting of the Los Angeles County Dental Society with the Los Angeles County Medical Association was held Tuesday, December 19, 1933. The following officers of the Los Angeles County Dental Society, elected at the November meeting, were installed: R. Leland Watson, president; Arthur W. Lufkin, president-elect; S. A. Allen, vice-president; H. E. Cannon, secretary; John W. Witty, treasurer. An illustrated lecture, "Further Studies by Newer Methods on the Relation of Focal Infection and Elective Localization of Streptococci in the Causation of Disease," was given by Edward C. Rosenow, M. D., Mayo Clinic, Rochester, Minn.

*Dr. McCoy Honored:* At the recent meeting of the American Society of Orthodontists, held in Oklahoma City, James D. McCoy was honored by being elected to the vice-presidency of that organization.

## FLORIDA

*Dr. Pattishall Editor:* H. B. Pattishall has been reelected editor of the *Florida Dental Journal.*

*Clinic Closed:* The Orange Dental Society Charity Clinic has been temporarily closed. Federal relief may take care of part of the work and it is proposed to reorganize as a clinic for children.

*State Society Officers:* The 1934 officers of the Florida State Dental Society are as follows: E. L. Thompson, president, Daytona Beach; George M. Shields, president-elect, Miami; C. P. Cleveland, first vice-president, Jacksonville; P. C. Harrell, second vice-president, Orlando; R. C. Cummins, secretary-treasurer, St. Petersburg; A. M. Smith, librarian, Tampa. Delegates to A. D. A. are as follows: C. J. Caraballo, Tampa; A. W. Sears, Jacksonville; F. L. Adams, Tampa; alternates: W. F. Andes, Miami; Edward L. Thompson, Daytona Beach.

*West Coast District Dental Clinic:* The Pinellas Dental Clinic for indigent children of the county has been in operation over two years. Formerly, the clinic took care of the children from the first to sixth grade inclusive, but this year it has been extended to include seventh and Junior High pupils as well. In the past year, 2,200 children were given the service. The work includes plastic fillings, extractions and general prophylactic attention. The clinic is employed for full time five and one-half days a week, the money for operation being furnished by the county commission.

*Dr. Forde gives Study Course:* The Tampa Society of Dental Surgeons had as its speaker on the evening of December 11, T. H. Forde, of San Francisco, Calif. At the conclusion of the program, Dr. Forde was asked to remain in Tampa to give a postgraduate course on the subjects that he had presented.

*Hospital Clinic:* The Miami Dental Society has recently taken over the establishment of a clinic at Jackson Memorial Hospital. Six men, Drs. Wilkerson, Ingraham, J. M. Cox, Alderman, Denault and Sanchez were appointed chiefs of individual groups in operative dentistry. Each group is to serve two months, thereby giving twelve months' service at the hospital.

## INDIANA

*Kosciusko Society Meets:* The Kosciusko County Dental Society held their regular monthly session in Warsaw, December 13. J. T. Waldo, of Indianapolis, spoke on "Extractions; Complications Arising in Every Day Practice."

*Isaac Knapp Society Meets:* The monthly meeting of the Isaac Knapp District Dental Society was held, December 6, at the Community Center in Fort Wayne. This was a dinner meeting starting at 6:30 with thirty-four members in attendance. After the dinner, the president, O. K. Hilty, presided at the business session dealing with matters before the society. T. F. Amey reported the progress of the dental survey that is to be made in this city.

*Northwest Society Activities:* The Northwest Indiana Dental Society suspended its regular December meeting and, in the interest of membership for 1934, to promote good fellowship and foster the Christmas spirit, held a dental stag party, December 20, open to all ethical dentists and laboratory and supply men of the northwest district.

## KANSAS

*Editor Addresses Kansas City Society:* Mr. Francis J. Gable, editor of *Good Business*, was guest speaker at the Kansas City Dental Society, Jan. 8, 1934. His subject was, "It Won't Hurt Much."

## MASSACHUSETTS

*Dr. Newell Made Mayor:* Gloucester, Mass., George H. Newell, 80-year-old practicing dentist, was elected mayor by the largest majority ever recorded in that city recently.

## MINNESOTA

*School Children Examined:* The Minneapolis District Society has taken a complete dental census of the school children of Minneapolis and of Hennepin County outside the city limits, under the leadership of Thomas P. Ryan, F. Denton White and W. H. Card. The dental examination of school children of Goodhue county has been about completed in the rural districts. Every dentist in the county is taking an active part in the survey.

## MISSOURI

*St. Louis Society Meets:* The St. Louis Dental Society held a meeting, January 8, at which Rudolf Kronfeld, Chicago, Ill., spoke on the subject, "How Can Microscopic Research Contribute to a Better Understanding of Clinical Oral Pathology?" At a meeting held February 5, the program included Floyd Alcorn, who spoke on "Dental Needs of School Children"; R. H. Miller, who spoke on "Dentists and the Depression" and Virgil Loeb, who spoke on "A Plan for the Dental Care of School Children."

*Society of Dental Science Meets:* The St. Louis Society of Dental Science held its regular meeting at the Mayfair Hotel, January 15, at 8:00 p.m. T. E. Purcell, dean of St. Louis University School of Dentistry, spoke on "Some of the Problems of Dentistry."

*New Publication:* The *Review of Dentistry*, published by the Ovid Bell Press, at Fulton, issued its first number in January, 1934. The editorial and publishing office are at 2002 Eaton Tower, Detroit, Mich.; managing director, Samuel D. Harris. This journal is the official organ of the American Society for the Promotion of Dentistry for Children. The *Review* will contain the business matters and programs of the society and of its component units.

## NEBRASKA

*Omaha Society Meets:* The regular January meeting of the Omaha District Dental Society was held at the Medical Arts Auditorium on the sixteenth of the month. Joseph D. McCarthy spoke on "What the Body Needs," and E. J. MacQuiddy spoke on "What the Body Refuses."

## NEW JERSEY

*Hudson County Society Meets:* At the regular meeting of the Hudson County Dental Society, February 2, at the Carteret Club in Jersey City, William J. Gies, professor of biologic chemistry, College of Physicians and Surgeons, Columbia University, spoke on "Current Problems in Dentistry." At the regular meeting of the society held on January 5, Charles F. Bödecker, professor of oral history and embryology, Columbia University Dental School, spoke on "Some Clinical Applications of Oral Histology and Oral Physiology."

*State Society Officers:* Officers of the New Jersey State Dental Society (1933-1934) are as follows: Robert E. Mulholland, president; Ernest J. H. Schneider, president elect; Edward J. Jennings, vice president; Frank K. Heazelton, secretary; George H. Griffith, treasurer.

*Emergency Relief:* A state society committee is formulating plans for cooperating with the Emergency Relief Administration and the Civil Works Administration to furnish dental treatment to those on the relief list and work for dentists in need of it.

*Questionnaire:* The Bureau of Economics is circulating a questionnaire to every licensed dentist in New Jersey in the compilation of statistics bearing on changing trends in dental practice.

*Dr. Burke on Board of Examiners:* J. Francis Burke, of Jersey City, presented his credentials to the state board, November 28, and entered on his duties as an examiner, succeeding Minot B. Stannard, of Ocean City, whose term had expired.

*Supreme Court Upholds Curb on Dentists' Advertisements:* Supreme Court Justice John T. Loughran (Kingston, N. Y.) has denied the application for a temporary injunction sought by dentists to restrain the enforcement of a rule of the New York State Board of Regents rigidly restricting advertising by dentists. The application had been filed by a group of New York City dentists.

## NEW YORK

*Joint Meeting Held:* The Third Annual Combined Meeting of the Organized Medical and Dental Professions of the City of New York was held in cooperation with the Greater New York Meeting for Better Dentistry. The following papers were presented: "Bleeding Gums—As an Expression of General Disease," by Eugene Marzullo; "Dental Infections as a Cause of Gastro-Intestinal Disease," by A. F. R. Andresen; "Development and Inheritance of Structural Types and Their Functional Significance," by Charles Stockard; "Correlation of Head Form and Type with the Development of Dental Structures," by A. LeRoy Johnson.

*Dental Assistants Meet:* At the meeting of the Educational and Efficiency Society for Dental Assistants, February 13, New York City, the Clinic Club presented "Preparation of Filling Materials."

*Hygienists Meet:* The Dental Hygienists Association of the City of New York held its regular monthly meeting, February 6. Sally Lucas Jean, consultant on public health, spoke on "Promoting Mouth Health Among Children in Different Parts of the World."

*Anesthesia Society to Meet:* A meeting of the American Society for the Advancement of General Anesthesia in Dentistry will be held March 26, 1934, at the Fraternity Clubs Building, New York City. W. H. Archer, D.D.S., will talk on "An Exhaustive Survey of the Causes of Mechanical Respiratory Embarrassment During Nitrous Oxid-Oxygen Anesthesia for Dental Surgery."

*Kings County Society Meets:* The mid-year meeting of the Kings County Dental Society was held February 15, at 8:30 p.m., at the Brooklyn Academy of Music. The evening was devoted to a symposium on "Oral Manifestations of General Systemic Diseases and Their Sequelae." Joseph Colt Bloodgood, of Johns Hopkins University, presented the medical side of the question and Lester R. Cahn, of Columbia University, gave the dental viewpoint.

*Graduating Classes Guests at Meeting:* The fourth stated meeting of the First District Dental Society was held February 5 at the New York Academy of Medicine, New York City. Members of the graduating classes of both New York University and Columbia University dental colleges were the society's guests at dinner and for the evening.

*Bronx Society Meets:* At the Bronx County Dental Society meeting held February 6, Arthur T. Rowe, New York City, associate dean of the Columbia College of Dentistry, spoke on "Full Dentures." The Section on Preventive Dentistry met February 14. Julius H. Levine of Boston, Mass., spoke on "Pulp Amputation, Its Justification and Technic." The Section on Pathodontia held a meeting February 19, at which the following essays were presented: "Etiology of Malocclusion" by Jerome H. Trier; "X-Rays in Orthodontia" by Sidney E. Riesner; "The Muscles of Mastication" by H. Shapiro; "How the Orthodontist Handles the Child" by J. Goldberg, and "The Responsibility of the Orthodontist" by S. L. Kregarman. At the meeting of the Section on Oral Surgery, February 21, Robert H. Ivy, Philadelphia, spoke on "The Restoration and Correction of Hard and Soft Tissue Defects on the Face and Jaws." At the meeting of the Section on Prosthodontia, held February 26, Louis Schorr, of New York City, spoke on "Bridgework."

*New Journal:* The American College of Dentists began the publication of a new journal in January of this year, under the title *The Journal of the American College of Dentists.* It will appear as a quarterly. Its board of editors are: John E. Gurley, San Francisco; Ervin A. Johnson, Boston; Howard C. Miller, Chicago; Elmer C. Hume, Louisville, and Charles E. Rudolph, Minneapolis.

## NORTH DAKOTA

*Dental Survey:* The dental survey proposed by the A.D.A. in conjunction with the Public Health Organization to ascertain the existing oral conditions of the children in grade schools and selected groups of adults in institutions will be carried on in North Dakota under the supervision of J. A. Chestnut, of Leeds.

## OHIO

*Welfare Survey:* Richard A. Bolt, director of the Cleveland Child Health Association, has just returned from a nine months' survey of maternal and child welfare conditions in Germany and Austria. This survey was conducted under an award from the Oberlander Trust of Philadelphia.

## RHODE ISLAND

*New Officers of State Society:* The officers of the Rhode Island State Dental Society for the year 1934 are as follows: president, Harry F. McKanna, West Warwick; vice president, Morris R. Lebow, Providence; treasurer, Francis A. Holland, Providence; secretary, Charles J. Smith, Providence; editor, Edward C. Morin, Pawtucket; librarian-curator, Mark Tichler, Newport.

## GENERAL

*Legislation:* Homer C. Brown, chairman of the Committee on Legislation and Correlation of the A.D.A., submits the following:

1. The Laboratory Code was approved January 22, becoming effective February 1. The most objectionable provisions of the first draft have been eliminated.

2. Under the regulations of the recent monetary act, approved January 31, 5 ounces of "unmelted scrap gold" may be held or transported, and a 25-ounce exemption is made for persons requiring gold for use in "the industry, profession or art," without the necessity of obtaining a license.

3. In all Federal and state legislation, such as "food, drug and cosmetic," "unemployment insurance" and "sales tax," it is quite important to give the dentist the same classification as the physician. Further, in "sales tax" legislation, it is strongly recommended that where "tangible personal property" is involved in rendering any type of health service, this be exempted, as it is illogical to place a tax on the promotion of health.

4. Favorable court decisions have recently been rendered in Wisconsin, Michigan, Illinois and Florida. The constitutionality of new dental laws, in the first three states, was involved. The state board secretaries of these states can furnish detailed information to interested persons.

5. To those dentists who are required to pay an income tax, attention is called to some deductible items which are frequently not included in the general office expense, as follows: dues in professional organizations; traveling expenses in attending professional meetings; professional journals and office periodicals; dues in chamber of commerce or similiar organizations; narcotic license fee; tax on club dues; local occupational tax; tax on checks; rental of safety deposit box; electrical energy; attorney fee in defense of malpractice suits, and premiums on liability and office equipment insurance. Those with hospital or other similar affiliations are entitled to deduct the portion of their automobile expense connected with that phase of their practice.

## FOREIGN

*Requirements for Candidates for Dental Degrees: Germany:* Dental education in Germany is conducted under the direction of the medical faculty of twenty-one of the twenty-two German universities. There is a professor of dentistry in each of the twenty-one faculties. The course is four and one-half years, which leads to the diploma conferring the right to practice and the title *Zahnartz.* A high school *(ober real schule)* or gymnasium course of eight years, preceded by a primary school course of four years is required for admission. This standard is higher than our American high school and would probably equal one year of college work in addition. The *ober real schule* gives the sciences rather than the gymnasium which gives the wider education in the "humanities."

*France:* In France, dental practice is permitted only by doctors in medicine, dental surgeons, licensed dentists and Alsatian dentists licensed under German rule. Doctors in medicine usually take an additional year and secure a state diploma in dentistry. Licensed dentists are those in practice prior to 1892 before which anybody could practice. The main body of French dentists are those who take the diploma *(Diplôme de Chirurgien-Dentiste),* which is awarded by the medical faculty of a university, after the completion of a course which may be secured partly in a medical school or a dental school or partly by study in the laboratory of an approved dental practitioner. It consists of five years, the last three of which must be in the dental school. The preliminary education required by law for this diploma (and hence for admission to the study of dentistry) may be met by presenting one of the four following certificates: 1. *Le baccalauréat complet (les deux parties),* which is equivalent to our high school course and probably one or two years of college. It is a secondary school diploma. 2. *Le brevet supérieur de l'enseignement primaire,* which is a normal school certificate. 3. *Le certificat d'études primaries supérieures,* which is only a primary school certificate. 4. *Le diplôme de fin d'études de l'enseignement secondaire de jeunes filles,* which is equivalent to our high school diploma. Thus it will be seen that the standard represented by the third of these certificates is that of a primary school, which in France covers six years of education only.

## BOOKS RECEIVED

*Mouth Hygiene*—A Textbook for Dental Hygienists. Fourth edition. By Alfred C. Fones. Published by Lea and Febiger, Philadelphia, Pa., 1933. Price, $7.00.

*Bacterial Infection*—With Special Reference to Dental Practice. By J. L. T. Appleton, Jr. Second edition, thoroughly revised. Published by Lea and Febiger, Philadelphia, Pa. Price $7.00.

DEATHS

*Ballou, P. D.*, Lagrange, Ind.; Indiana University School of Dentistry, 1896; died, November 17.

*Boyle, Stanley L.*, St. Louis, Mo.; Washington University School of Dentistry, 1911; died recently.

*Burkett, C. W.*, Plymouth, Ind.; Northwestern University Dental School, 1910; died recently.

*Chamberlain, W. A.*, St. Louis, Mo.; University of Michigan, School of Dentistry, 1898; died recently.

*Colburn, L. P.*, Grand Forks, N. D.; died, November 23.

*Couplin, C. A.*, Washington, D. C.; University of Minnesota, College of Dentistry, 1898; died recently, aged 59.

*Cumming, W. A.*, Portland, Ore.; St. Louis Dental College; died, November 25; aged 74.

*Dabney, A. S.*, Chicago, Ill.; Baltimore College of Dental Surgery, 1884; died recently, aged 72.

*Franken, S. W. A.*, New York City; New York College of Dentistry, 1909; died, December 13; aged 45.

*Holmes, J. H.*, Brooklyn, N. Y.; New York University College of Dentistry, 1894; died, November 22.

*Johnson, Edward E.*, Chicago, Ill.; Chicago College of Dental Surgery, 1899; died recently; aged 60.

*Jungman, J. W.*, Cleveland, Ohio; University of Michigan School of Dentistry, 1889; died January 10; aged 67.

*Kainpfe, C. J.*, Cleveland, Ohio; Western Reserve University School of Dentistry, 1909; died recently; aged 48.

*Marshall, M. C.*, St. Louis, Mo.; Temple University of Dentistry, 1880; died recently.

*Mouser, S. L.*, Indianapolis, Ind.; Indiana University School of Dentistry, 1916; died November 12; aged 41.

*Printz, M. M.*, Chicago, Ill.; Northwestern University Dental School, 1904; died, February 12.

*Rees, Lester A.*, Connersville, Ind.; Indiana University School of Dentistry, 1921; died November 15.

*Stahle, Helen R.*, Hollywood, Calif.; University of Iowa College of Dentistry, 1910; died, December 12.

*Thomason, A. R.*, Hankinson, N. D.; Northwestern University Dental School, 1908; died, November 8.

*Thompson, W. I.*, West Allenhurst, N. J.; Temple University, 1902, died recently; aged 60.

*Wonderly, T. G.*, Galena, Ill.; Philadelphia Dental College, 1877; died, December 1; aged 82.

## CURRENT LITERATURE

*Metabolic Studies of Children with Dental Caries (J. D. Boyd, C. L. Drain and Genevieve Stearns, J. Biol. Chem., December, 1933):* The authors assert that control of dental caries depends on diet, but that no agreement prevails as to mechanisms involved in safeguarding the teeth against decay. The proponents of the "humoral" theory claim that the susceptibility of the teeth to decay is determined by the concentration of the inorganic constituents of the fluid that comes in contact with the teeth. If this is as the authors contend, it should be possible of demonstration. For seven years, they have made detailed examinations of patients admitted to the children's orthopedic service of the Children's Hospital. Methods and results are tabulated. They conclude that the levels of serum calcium and phosphorus and the acid-base relationship are not primarily of significance in production or prevention of dental caries. This is true of the chief constituents of the saliva. They see no evidence that dietary deficiency of phosphorus is an outstanding factor in the incidence of caries or that acid-base imbalance induced by any ordinary diet is responsible. They indicate a close relationship between the metabolic efficiency of the organism as a whole and the resistance of the tooth to decay, the latter being dependent primarily on conditions operative within the tooth. Also the authors suggest that the optimum retention of calcium and phosphorus may be higher than that usually accepted as adequate.

*Retardation of Dental Caries in Outpatients of a Dental Infirmary; Preliminary Study (Percy R. Howe, Ruth L. White and Milton Rabine, Am. J. Dis. Child., November, 1933):*

The authors mention the skepticism of the profession regarding reports made on the arrest of caries through dietary changes in the various children's institutions in this country and in England. Likewise, they mention the doubt of the profession that it is feasible for dentists to carry out such a regime in private practice. The summary given is the preliminary findings of a recent survey carried on at the Forsyth Dental Infirmary: 1. In the preliminary findings of a study of 132 patients followed for dietary supervision over a period of one and six tenths years, an average reduction of dental caries of 79.21 per cent was observed in 104 cooperative patients. In twenty-eight noncooperative patients, an average increase in dental caries of 12.97 per cent occurred. This increase compares with the expectancy for the average age of the group studied, which was 6 years. 2. The conditions under which the study was made strongly suggest that a similar project can be successfully carried out in the office of the dental practitioner with a knowledge of nutrition and an understanding of methods of interesting his patients in dietary improvement.

*Rôle of Pharmacology in the Development of Ideal Anesthesia (C. D. Leake, J.A.M.A., Jan. 6, 1934):* Leake says that clinical trial of a new chemical should be made only after pharmacologic study has estimated it in comparison with related agents, possible harmful effects, mode of action and the reasonableness of its replacing other existing drugs on application to human beings. It should not be offered to practitioners until favorable reports had been published from reputable chemical, pharmacologic and clinical sources. Such data are more acceptable from university laboratories than from commercial laboratories. Practitioners would show greater confidence in commercial concerns if they would cooperate with such laboratories rather than endeavor to supplant them. Both toxicity and efficiency must be thoroughly investigated. A great variety of adjuncts to anesthesia have been proposed for preanesthetic hypnosis regulation of metabolism preoperatively, aid in induction maintenance and prompt recovery, relief from postanesthesia nausea and postoperative analgesia. He discusses the common ones frankly and speaks of the commercial exploitation of many. He believes that hypnotics more satisfactory than those now in use may be found. Unfortunately, commercial houses have dominated the field so that dependable data have been difficult to obtain. A cooperative therapeutic institute has been suggested, but commercial houses were unwilling to establish and support it.

*Anesthetics, Narcotics and the Sick Man (George Crile, Am. J. Surg., January, 1934):* In past years, anesthetists believed the mechanism interfered with by anesthetics was the brain, that changes in brain cells followed prolonged inhalation. Next, it was found that there was a steady decrease in the temperature of the brain during anesthesia, indicating decreased oxidation and decreased electric conductivity, and then that the electric potential of the brain decreased. But this did not explain failure of heart, kidney and liver function following anesthesia. The secret, Crile says, is in the identical character of the protoplasm of all animal tissues. All tissues contain proteins, lipoid electrolytes in certain proportions. Every tissue has an optional electrical potential; in anesthesia that potential is lowered, and when it reaches zero, the organ or tissue is dead. Anesthetics interfere with the genesis of bio-electric currents and the short wave radiation of normal activity. Local anesthetics do this for the part injected. Inhalation anesthesia is analogous to death. All tissue and organs are involved in it as in death. The brain, being the most active tissue, is most profoundly affected. But the other organs are too. If those organs are diseased, they are further depressed by the anesthetic. Hence, if the organ is depressed from the low level of the disease to zero, the patient dies, not of the disease, but the anesthesia. Anesthetics are safe enough if the organs are normal. It follows that before general anesthesia, the state of protoplasm of the essential organs must be known. Crile says that of the general anesthetics, nitrous oxid-oxygen and ethylene are the safest. Their effects are the most fleeting. The safest procedure when general anesthesia is demanded is to give nitrous oxide-oxygen until analgesia is attained, and then rely on local, regional, splanchnic or spinal anesthesia.

### Foreign Literature

*Stainless Steel for the General Practitioner and for the Orthodontist (F. J. H. Barr, New Zealand D. J., November, 1933):* Barr names a half-dozen stainless steels manufactured in Germany, England and the United States. These steels, because of the nickel and chromium in them, do not harden when heated and quenched, but rather are made malleable by the process. They are hardened by cold working and resoftened by heating to 1150 C. or

yellow heat. It may be air or water cooled. Oxidation may be reduced to a minimum if the steel is heated in a bath of common salt in a nichrom crucible. He emphasizes that mechanical work is the only means of rehardening these steels, which presents a disadvantage to orthodontists. One company indicates that its product could not be soldered but had to be welded to maintain its monopoly. But, Barr asserts, the soldering is relatively simple. He lists methods of soldering which were tried and which failed. A special flux held the secret. This contains boracic acid powder and potassium fluoride in equal proportions, prepared by mixing aqueous solutions of each constituent, evaporating to dryness and crushing the residue. Barr mixes the powders in a mortar, and when they become pasty, uses the product. To maintain this condition, a few drops of water may be added. He prefers this to the preparations of manufacturers. He sees no advantage in welding over soldering. Methods for gold plating, descaling and polishing and the making of bands and arch wires are given. The technic for making arch wires and bands is affected by the impossibility to retemper. All heating must be kept at a minimum, being used only for soldering. The main arch wires must be bent cold. The points where soldering is done scarcely affect the spring of the wire.

*Matters of Present Interest to the Dental Profession (F. W. Craddock, New Zealand D. J., November, 1933):* Three problems are considered: 1. The adequate treatment of the poor and the general public. 2. The adequate treatment of school children. 3. Dental educational publicity.

The object of the writer is to point out the essential conditions which the association must consider in determining its activities. He concludes: 1. The provision of *simple* dental services for the poor is the function of the state to be paid for by the state. 2. The state having embarked on, and accepted the responsibility for, the school clinic scheme, should expand or reorganize it entirely within the existing organization. 3. State dentistry, private dentists and the broadcasting authorities should cooperate in dental educational publicity.

*Avoiding Dry Socket (F. D. Gratrix, Brit. J. D. Sc., January, 1934):* Gratix quotes Fleming to give emphasis to his thesis that dentistry has been slow to place more reliance on the defensive powers of the body and less on the more destructive powers of the chemical antiseptics. Alarmed at the occurrence of dry socket following both local and general anesthesia, he determined to discard chemical antiseptics and rely on physiologic reaction and drainage. He regards bruised bone from instrumentation or hypercementosis of nodular roots as the cause of dry sockets, although sepsis in a root may be the source. Success in the use of glycerine in puerperal sepsis gave him his idea of treatment. If it was so efficient in such virulent streptococcal infection, it might be valuable in dry socket. Also, it had been used for cellulitis, lymphangatis, tuberculosis and peritonitis with success. It is inhibitive rather than bactericidal. It is vastly superior to potassium permanganate. It induces a free flow of lymph from the walls of the wound, which causes defending cells and bacteria to gather. It may also be used as a routine application, whether there is suspicion of infection or not. No healthy cells will be destroyed. The effect of adrenalin is overcome and a good blood clot induced and in a shorter time. Pure glycerine with no added antiseptics is used. The stock should be boiled frequently, care being taken to keep steam from the glycerine, which is applied with a curve dropper and placed in the socket before the saliva enters, if possible. No rinsing is allowed for some minutes after application.

*Significance of Vitamins in Practical Experience (L. J. Harris, Brit. M. J., Aug. 26, 1933):* The writer states that proper nutrition cannot be left undirected. Official reports show that from 80 to 90 per cent of the elementary school population in London had variable degrees of rickets. He attributes to the climate the appearance of rickets in a large proportion of instances, many of which are severe unless prophylactic measures are taken. No common foodstuff contains enough antirachitic vitamins. While cod liver oil is a valuable remedy, it is often impracticable to give enough of it to assure protection. Experience shows viosterol to be the most dependable remedy as it can easily be given at a standardized level. He stresses proper dosage, as an excess may cause hypervitaminosis. He recommends a dose of 1,500 international units for prophylaxis and from 3,000 to 5,000 for curative treatment.

*Gangrenous Phlegmons of Buccal Dental Origin (Gerard Maurel, L'Odontologie, October, 1933):* By gangrenous phlegmons of buccal dental origin, the author does not mean Ludwig's angina only, but that and all similar conditions. These complications result, Maurel says, from gangrene or mortification of the

pulp and from caries. They may come from either upper or lower teeth. They occur usually after extraction, accompanied by general debility and fatigue. Anaerobic bacteria are the chief cause of the disturbances and not the technic of or the actual extraction. These bacteria produce gas gangrene. Other bacteria may be present, the most common variety being the streptococci. The pathologic process is a cellulitis. The author shows the extent to which these lesions may spread into the neck, following the muscle sheaths, or the side of the face to the temple. They may be superficial, or deep, involving the sinuses and spreading to the orbital region. A thorough diagnosis is presented to emphasize the importance of its being made early as the disease frequently proves fatal when allowed to go to its third stage. The salient diagnostic points are a black discoloration of the tissue, induration and an absence of swelling and of redness, the usual signs of common phlegmon. In other words, there is a scarcity of local symptoms, which in itself is an aid to diagnosis but which easily escapes cursory examination. When diagnosis is made, the treatment must be begun as quickly as possible. There are two therapeutic methods which must be applied concurrently, the surgical and serotherapeutic. The writer gives his surgical technic and states that a polyvalent gangrene antiserum and a streptococcic antiserum should be used during surgical intervention. It must be remembered that the patient is a victim of intoxication and the kidneys and the heart must be watched, while tonics and stimulants should be administered when necessary. In conclusion, the author refers again to the two dental conditions which are the cause of the gangrene. He insists that the dentist must not be blamed for the extraction which may have caused the phlegmon and that the causative tooth should be extracted because, if it remained, it would continue to be a source of infection.

*Adamantine Epithelioma of the Lower Jaw, Surgical and Prosthetic Therapy (Gerard Maurel and M. Macary, Rev. Odontologique, November, 1933):* Adamantine tumors of the lower jaw are rare and, for that reason, each case should be published. The authors present a case which is interesting particularly because of its long duration. It had begun to develop in 1911, and, at the time it was first seen, in 1930, it had become very large, with considerable facial deformation. The tumor adhered to the soft tissue and invaded the parotid gland. After the diagnosis, a prosthetic appliance was made, and the tumor was removed. The results of the operation seemed to be good, since, after two and one-half years, there had been no recurrence. The authors stress the interest of this case on the basis of differential diagnosis and therapy. Because of the long period of development, they believed the diagnosis of adamantine epithelioma to be justified. They point out that this tumor is nearly always located at the angle of the lower jaw. The consistency of the tumor is quite characteristic in palpation because it is composed of a series of adjacent cysts. A fistula frequently accompanies these tumors with a characteristic serous liquid draining from it. Around this fistula, there are fleshy masses. These tumors are indolent, their evolution being practically painless. An interesting relationship between the dental system and the tumor is suggested, but no definite conclusion is reached because in no case have these authors ever found a tooth within a tumor. In some cases, teeth are missing in the affected arch, but this is not always the case. The absence of adenopathies is an important negative sign. Aside from these clinical symptoms, diagnosis may be aided by means of exploratory puncture, roentgenography and biopsy. Operation is the only therapy suggested in this situation. The authors give their technic for the operation. Prosthetic appliances should be made before the operation to prevent postoperative deformity and to aid in functional readjustment of the jaws.

*Mucous Membrane of the Tongue at Different Periods of Life (W. Ehrlich and F. Ehlert, Deutsche Monatschr. Zahnheilk., 1933, pp. 866-880):* The thickness of the tongue epithelium increases until the sixty-fifth year of life, then decreases with a steep curve. The epithelium of the anterior and upper surfaces grows to a much greater thickness than that of the lower and posterior surfaces. This difference in thickness affects mainly the thickness of the epithelium of the papillae. The tongue becomes regularly hornified from childhood on, the anterior portion being more hornified than the posterior portion. This process of hornification is a true one, with the formation of hyalokeratin and loss of nuclei in the uppermost layer of epithelium with the formation of keratin. After the age of 65, the markedly hornified tongue has a thicker epithelium, while the lesser hornified tongue has a very thin epithelium. Eighty

per cent of tongues examined by the authors showed transitions from light to heavy to, finally, ulcerative forms of inflammation diffused in the epithelium and connective tissue. The anterior surface of the tongue is more involved than the posterior. The greater thickness, the stronger hornification and the heavier inflammation of the anterior portion of the tongue are due to the fact that this part of the tongue comes more in contact than does the posterior part with solid and liquid foods. That the grade and frequency of inflammation decreases with increased hornification proves that the process is a protective mechanism against physiologic irritation to the tongue. In many tongues, there occurs the formation of a thick elastic network between the epithelium and the musculature, which increases with age and is thicker in the posterior part. It is most common in senile atrophy.

*Ramifications in Root Canals of Human Teeth, Especially in Anterior and Bicuspid Teeth (Karl Schulz, Deutsche Zahnartzl. Wchnschr., 1933, pp. 180-184):* The author reports his histologic study on single and double rooted teeth. His investigations show that most of these roots have a complicated anatomic variation, such as double root canals, which may divide and subdivide into lateral canals and various ramifications. Physiologic influences are in most cases responsible for these anatomic variations. They may also arise as a result of pathologic processes. These anatomic variations play an important rôle in root canal therapy.

*Age Changes in Dentin (H. Gerlach, Morphol. Jahrbuch, 65:481, 1931):* In the dentin there are the so-called calcium lamellae which are analogous to Ebner's dental lamellae. These calcium lamellae show different quantitative calcium contents in different layers of the teeth. The crown is richer in calcium than the root portion. The older layers of dentin contain more calcium than the younger layers. With an increase in age, the calcium content of the inner zone increases, but it is never so high as that of the older layers. From a mechanical point of view, the higher calcium content in the crown is useful, since the latter is exposed to greater stress. This study was based on the incisors of cattle.

*Capillary Picture of the Lip Mucosa After the Loss of Teeth (S. Bettmann, Deutsche Monatschr. f. Zahnheilk., 49:577, 1931):* The capillariscopic study of the mucosa of the lower lip shows a simplification of the capillaries and a decrease in their number with age. Disease conditions, such as lupus of the face, produce various alterations in different portions of the lip. A woman, aged 32, whose uterus was completely removed ten years before showed a prominent senile change in the capillaries indicating the endocrine influence on the blood vessels. In general, on the basis of the constitutional type and temperament of the patient, there develops subsequent to the loss of teeth in one or both jaws a reduction in the number of capillaries or a senile change.

*Teething Difficulties (F. Rothenberg, Med. Klin., March 4, 1932):* Difficulties with teething in infancy are the rule, and the skeptical attitude of medical science is not justified. The cutting of the teeth is not an active process as it was thought to be. It has nothing to do with pushing the teeth upward through growth of the root. This theory overlooked entirely the simultaneous growth of the jaws. Landsberg's studies have shown that the growing tooth does not move. It is really carried to the surface of the jaw through the growing alveolus, while the resorption of the alveolar roof brings the crown of the tooth more and more to a prominence. Therefore, from the physiologic point of view, the teething ring has certain significance and justification. Through biting on this ring, increased pressure is produced, which helps the resorption of the alveolar roof and stimulates the uncovering of the dental crown.—Abstr. *Am. J. Dis. Child.*, November, 1933.

*Organization of Systematic Dental Care of School Children in the Czechslovak Republic (Bedrich Newmann, Sborn. lek., February, 1931):* The author outlines his suggestion as follows: There is necessity for dental work because of gross dental caries (in from 95 to 97 per cent) and because of the sequelae (health, social and economic). The present organization is of limited scope. Dental hygiene requires executive and medical and dental organization. The financial structure involves equipment, organization and material. Financing could be carried out through cooperation of parents, public funds and insurance funds (health insurance). In smaller communities the use of the automobile ambulance equipped as a mobile dental dispensary is suggested. Photographs of such an ambulance are presented.—*Am. J. Dis. Child.*, November, 1933.

*Anodontia Congenita Vera (Jan Fridrichovsky, Sborn. lek., August, 1931):* The author reviews the literature and discusses the various theories of anodontia. A girl of 4 years came

to the clinic, and, on examination, only seven teeth were found in her upper arch. These were the upper incisors and cuspids and the left first molar. Her first tooth erupted at 6 months and her developmental history was normal. She had had pertussis and bronchitis and was well developed and well nourished. Her mother had typhoid fever during pregnancy. Roentgenograms revealed the following tooth buds in addition to the aforementioned erupted teeth: first and second molars (upper and lower). The lower jaw was poorly developed, and the alveolar arch where no teeth had erupted was atrophic. No other gross defect was noted.—*Am. J. Dis. Child.*, November, 1933.

*New Biologic Investigations of Human Teeth (Guido Fischer, Tandlaegebladet, November, 1933):* This is the result of a study of case histories and serial sections of about 900 teeth. It is richly illustrated with microphotographs. Dr. Fischer is of the opinion that owing to the narrowing down of the apical foramen, pulp stasis sets in early in the adult tooth. This stasis—hydrops pulpa—starts in youth and is physiologic. The atrophic or reticular pulp is not a phase of necrosis, but different stages of the normally developing stasis. The fact that the circulation in the pulp is practically a closed one is given as the reason for the vitality of the pulps in teeth involved in the most severe cases of paradontitis, osteomylitis and infected cyst. Considering this fact, one should never remove loose teeth in such cases, if they are intact. Fischer insists that the dental pulp has no lymphatics; this, of course, tends to increase the speed of formation of the hydrops pulpa. "The pulp is the most basic tissue in the whole organism ($p_H$ 7.44, after Csernyei). It is more basic than other connective tissues ($p_H$ 7.2). All influences tending to acidify the pulp meet with considerable resistance." The buffer action of the pulp is great. This is the reason that the pulp does not die after coming in contact with relatively large amounts of acid in deep caries. If, finally, the source of the acid is removed, i.e., the cavity properly filled, repair, started as soon as the acid influence was noticed, is completed. If the pulp is overpowered with acid, its death is inevitable. This is the reason for the many pulp deaths under deep silicate fillings in anterior teeth. Drawing his conclusions from these studies, Dr. Fischer advises proceeding very slowly with orthodontic treatment so as not to interfere with normal metabolism in the teeth. In root canal treatment, one should not use poisonous drugs such as tricresol paste, which prevent the closure of the apical foramen with cement substance and dense scar tissue. The extirpation method is particularly dangerous because it favors secondary infection of the deep portions of the root. The amputation method is by far the method of choice.

*Skin Emphysema in Connection with Dental Treatment (George Bremer, Svensk Tandlak. Tidskr. 5:336, 1933):* Dr. Bremer's case of emphysema of the face—air in the subcutaneous connective tissue—presents a relatively rare occurrence in connection with dental treatment. In this particular case, the air was forced through the open root canal in an upper left second bicuspid, into the maxillary sinus, and from the sinus, through bone canals into the external soft tissue. The swelling, which immediately closed the left eye, subsided in six days after treatment under infrared therapy and boric acid compresses.

*Mouth Cavity as a Diagnostic Means in Many Diseases (A. Geordasdis, Greek D. Rev., October, 1933):* Dr. Geordiadis says that the dentist of today is responsible for a greater service than the repairing or the making of teeth. His opportunity to observe signs of extensive disturbance throughout the body and of informing the patient and the patient's physician must be appreciated for the patient's benefit. He notes the indications on lips and tongue of syphilitic infection; likewise the presence of scrofula as shown by a thickening and coarseness of the upper lips, accompanied by a muddy appearance of the lips, a lowered resistance and proneness to eczematous eruptions, ulcerous glandular swelling, respiratory catarrh and tuberculosis of glands, lungs or bones. The lower lip is rarely swollen in such cases, in contrast with the condition found in patients having profound brain changes, such as morons or paralytics. Red, bleeding, ulcerated gums suggest the presence of anemia or chlorosis; purplish, spotted gums, suprarenal infection; yellowish gums, a diseased liver, and bluish gums, systemic poisoning. The presence of diseased teeth indicates a fault in metabolism, and, therefore, other organs of the body may easily be involved. Caries indicates a general imbalance, which should be diagnosed and treated. Endogenous pulpitis may be caused by arterial conditions, age, thrombosis, diabetes, or alcoholism, low vitality or shock or other nervous disturbances. It may be due to abnormal endocrine secretion. The condition

of the epithelium of the palate may indicate fevers, cyanosis or measles. In jaundice, the yellowish appearance is evident first in the mouth and in the eyes. Enlarged or underdeveloped tongue with splits or spots, or if swollen, may reveal endless disorders. Halitosis may be due to dietary, local or systemic upsets. Excessive salivary secretion may follow metallic poisoning, irritation of glands from drugs, facial neuralgia, disturbed digestive function or irritation of the tympanic cord. Lack of saliva, or the presence of saliva that is ropy, acid or alkaline in reaction, may have equal diagnostic value.

## ANNOUNCEMENTS*

### CALENDAR OF MEETINGS

American Dental Association, St. Paul, Minn., August 6-10.

American Dental Society of Europe, Holland, August.

American Public Health Association, Pasadena, Calif., September 3.

Association of American Women Dentists, St. Paul, Minn., August 6.

American Society of Oral Surgeons and Exodontists, St. Paul, Minn., August 3-4.

Chicago Dental Society Midwinter Clinic, February 26-March 1.

Congress of Radiology, Zurich, Switzerland, July 24-31.

Five State Post Graduate Clinic, Washington, D. C., March 19-21.

International Congress of Radiology, Zurich, Switzerland, July 24-31.

Society for Advancement of General Anesthesia in Dentistry, New York City, third Monday in February, April, October and December.

Southern Academy of Periodontology, Atlanta, Ga., March 14.

Southern Society of Orthodontists, Hot Springs, Va., July 16-17.

Thomas P. Hinman Midwinter Clinic, Atlanta, Ga., March 12-13.

District of Columbia, at George Washington University, Washington, D. C., second and fourth Tuesdays in each month from October to June, inclusive.

### STATE SOCIETIES

#### March

Minnesota, at St. Paul (3-4) (Business meeting only)

#### April

Alabama, at Montgomery (23-25)
California, at San Francisco (5-7)
Connecticut, at New London (18-20)
Kentucky, at Louisville (9-11)
Louisiana, at Shreveport (19-21)
Michigan, at Grand Rapids (9-11)
Mississippi, at Jackson (16-18)
Montana, at Missoula (12-14)
New Jersey, at Atlantic City (25-27)
Tennessee, at Chattanooga (26-28)
Texas, at Fort Worth (24-26)
Virginia, at Charlottesville (30-May 2)
Wisconsin, at Milwaukee (17-19)

#### May

Arkansas, at Little Rock (14-16)
Illinois, at Springfield (8-10)
Indiana, at Indianapolis (21-23)
Iowa, at Cedar Rapids (1-3)
Kansas, Missouri and Oklahoma (Tri-State) 6-9
Maryland, at Baltimore (7-9)
Massachusetts, at Boston (7-9)
Nebraska, at Lincoln (21-24)
New York, at Buffalo (9-12)
Pennsylvania, at Pittsburgh (1-3)
South Dakota, at Mitchell (14-15)
Vermont, at Burlington (16-18)
West Virginia, at Clarksburg (21-23)

#### June

Southern California, at Los Angeles (4-6)
Georgia, at Atlanta (11-13)
Maine, at Augusta (22-23)
New Hampshire, at Lake Sunapee (27-28)
North Carolina, at Wrightsville Beach (18-20)
Oregon, at Portland (20-23)
Washington, at Tacoma (14-16)

### STATE BOARD OF DENTAL EXAMINERS

New Jersey, at Trenton, June 25-30. John C. Forsyth, Secretary, 148 W. State St., Trenton.

California, at San Francisco, May 21, and Los Angeles, June 18. Kenneth I. Nesbitt, Secretary, 450 McAllister St., San Francisco.

*Announcements must be received by the fifth day of the month in order to be published in the forthcoming issue of THE JOURNAL.

Connecticut, at Hartford, June 27-30. Almond J. Cutting, Recorder, Southington.

Maine, at Augusta, June 25-27. Alton H. Swett, Secretary, 192 State St., Portland.

Mississippi, at Jackson, June 19-21. T. Ford Leggett, Secretary, Laurel.

Ohio, at Columbus, June 25. Morton H. Jones, Secretary, 1553½ N. Fourth St., Columbus.

Rhode Island, at Providence, June 26-28. Albert L. Midgley, Secretary, Union Trust Bldg., Providence.

Virginia, at Richmond, June 12. John M. Hughes, Secretary, Medical Arts Bldg., Richmond.

### CALIFORNIA STATE DENTAL ASSOCIATION

The annual meeting of the California State Dental Association will be held in San Francisco, April 5-7.

ROBERT M. LEGGETT, *General Chairman,*
490 Post St.,
San Francisco.

### COLORADO STATE DENTAL ASSOCIATION

The next annual meeting of the Colorado State Dental Association will be held in Colorado Springs, June 18-20.

BERTRAM H. DOWNS, *Secretary,*
Exchange Nat. Bank Bldg.
Colorado Springs.

### LOUISIANA STATE DENTAL SOCIETY

The fifty-fourth annual meeting of the Louisiana State Dental Society will be held April 19-21, at the Washington-Youree Hotel, Shreveport.

JULIAN S. BERNHARD, *Secretary,*
Medical Arts Bldg.,
Shreveport.

### MAINE DENTAL SOCIETY

The sixty-ninth annual meeting of the Maine Dental Society will be held at the State House, Augusta, June 22-23.

GEORGE A. PHILLIPS, *Secretary,*
31 Central St.,
Bangor.

### MISSISSIPPI DENTAL ASSOCIATION

The next meeting of the Mississippi Dental Association will be held in Jackson, April 16-18.

M. L. JONES, *Secretary,*
Meridian.

### OREGON STATE DENTAL ASSOCIATION

The annual meeting of the Oregon State Dental Association will be held at Portland, June 20-23.

F. W. HOLLISTER, *Secretary,*
Medical-Dental Bldg.,
Portland.

### PENNSYLVANIA STATE DENTAL SOCIETY

The sixty-sixth annual meeting of the Pennsylvania State Dental Society will be held at the William Penn Hotel, Pittsburgh, May 1-3.

W. HARRY ARCHER, *Chairman,*
Publicity Committee,
May Bldg.,
Pittsburgh.

### BOARD OF DENTAL EXAMINERS OF CALIFORNIA

The next examination of the Board of Dental Examiners of California will be held in San Francisco beginning May 21, and in Los Angeles beginning June 18. All credentials must be in the office of the secretary twenty days prior to the date of examination. For further information, address

KENNETH I. NESBITT, *Secretary,*
450 McAllister St.,
San Francisco.

### CONNECTICUT DENTAL COMMISSION

The Connecticut Dental Commission will meet in Hartford, June 27-30, for the examination of applicants for license to practice dentistry and dental hygiene and to transact any other business proper to come before it. Applications should be in the hands of the recorder at least ten days before the meeting. For application blanks and further information, apply to

ALMOND J. CUTTING, *Recorder,*
Southington.

### BOARD OF DENTAL EXAMINERS OF THE STATE OF MAINE

The annual meeting of the Maine Board of Dental Examiners will be held at the State House, Augusta, June 25-27 for examination for registration of dentists and hygienists. Further information, application blanks, etc., may be obtained by applying to

ALTON H. SWETT, *Secretary,*
192 State St.,
Portland.

### MISSISSIPPI STATE BOARD OF DENTAL EXAMINERS

The next meeting of the Mississippi State Board of Dental Examiners will be held at Jackson, June 19-21.

T. FORD LEGGETT, *Secretary,*
Laurel.

### OHIO STATE DENTAL BOARD

The next examination of the Ohio State Dental Board will be held at the College of Dentistry, Ohio State University, Columbus, the week beginning June 25. All applications must be in the hands of the secretary at least ten days before the date of the examination. For further information, apply to

MORTON H. JONES, *Secretary,*
1553½ N. Fourth St.,
Columbus.

### RHODE ISLAND BOARD OF REGISTRATION IN DENTISTRY

A meeting of the Rhode Island Board of Registration in Dentistry for the examination of applicants for license to practice dentistry and dental hygiene will be held at the State House, Providence, June 26-28. Candidates shall present to the secretary of the board, at least ten days before the examination, an application with fee and photograph. For applications and further information, address

ALBERT L. MIDGLEY, *Secretary,*
1108 Union Trust Bldg.,
Providence.

### VIRGINIA STATE BOARD OF DENTAL EXAMINERS

The next regular meeting of the Virginia State Board of Dental Examiners will be held at the Medical College of Virginia, Richmond, June 12. Applications, with fee and photograph, must be filed fifteen days before the examination. For application blanks and further information, apply to

JOHN M. HUGHES, *Secretary,*
Medical Arts Bldg.,
Richmond.

### AMERICAN SOCIETY OF ORAL SURGEONS AND EXODONTISTS

The sixteenth annual meeting of the American Society of Oral Surgeons and Exodontists will be held in St. Paul, August 3-4.

HARRY BEAR, *Secretary,*
Professional Bldg.,
Richmond.

### ASSOCIATION OF AMERICAN WOMEN DENTISTS

The thirteenth annual meeting of the Association of American Women Dentists will be held at the St. Paul Hotel, St. Paul, August 6.

GENEVA E. GROTH, *Chairman,*
Publicity Committee,
Medical Arts Bldg.,
Philadelphia, Pa.

### BRONX HOSPITAL DENTAL APPOINTMENTS

Several vacancies on the dental staff of the Bronx Hospital exist, permitting a number of appointments to be made in the various departments of dentistry. Applications may be made to the Bronx Hospital, Fulton Ave. at Sixty-Ninth St., New York City.

DAVID WURZEL, *Chief of Clinic,*
3036 Perry Ave.,
Bronx, New York.

### CLASS OF 1904, DENTAL SCHOOL OF UNIVERSITY OF MARYLAND

The class of 1904 of the Dental School of the University of Maryland will hold a reunion at the time of the annual meeting of the Maryland State Dental Association, May 7-10, at the Lord Baltimore Hotel, Baltimore. All class members are asked to communicate with the secretary.

WALTER E. GREEN, *Secretary,*
2958 W. North Ave.,
Baltimore.

### CONGRESS OF RADIOLOGY

The fourth international Congress of Radiology will be held in Zurich, July 24-31. The detailed program containing information as to accommodations and travelling facilities will be sent to all registered members. On application, a copy will be sent to members of radiologic societies who have not up to the present registered their names with the committee. Communications and summaries to discussions and sectional meetings must be received by April 1; photographs, titles, etc., by June 1. July 1 is the latest date for the acceptance of members. Address all correspondence to the Secretariat, Fourth International Congress of Radiology, Gloriastrasse 14, Zurich, Switzerland.

### PRELIMINARY PROGRAM NEW YORK STATE DENTAL SOCIETY

The Dental Society of the State of New York will hold its sixty-sixth annual meet-

ing in Buffalo, New York, May 9, 10, 11 and 12, 1934. Literary exercises, exhibits, etc., will be held at the Hotel Statler. The Executive Council will convene for the transaction of the business of the society, May 9. During the time of the meeting, sessions of the New York State Dental Hygienists' Association and the Dental Assistants' Association will be held. Headquarters will be in the Hotel Statler and reservations should be made direct with the hotel management. For further information with reference to the literary exercises, clinics, etc., apply to

A. P. BURKHART, *Secretary*,
57 E. Genesee St.,
Auburn.

## THE JOURNAL OF PERIODONTOLOGY

This journal is published by the American Academy of Periodontology as an independent medium of expression to stimulate interest in periodontia and to record the development of this important phase of dental practice.

"The Journal of Periodontology is published to serve as the professional journal of periodontia; to keep dentists in touch with research in this and related fields; to stimulate greater interest in the supporting tissues of the teeth and their relation to the general health. It contains original papers of scientific interest, the proceedings of the American Academy of Periodontology, and abstracts of current dental literature relating to periodontia. The abstracts alone make the journal a permanent fund of information readily available to teachers, researchers, clinicians and students."—*J. D. Res.*, 12:2, 1932.

There are copies of the January 1931, 1932 and 1933 and July 1931, 1932 and 1933 issues to be had at $1 each. The January number, 1931, contains a bibliography of periodontia, 500 B.C. to 1931 A.D., and 189 abstracts of current literature, 1927, 1928, 1929, on histopathology, bacteriology and other laboratory research. The July, 1931, number contains original papers and 209 abstracts on clinical etiology, symptomatology and diagnosis. The January, 1933, issue contains proceedings of the annual meeting of the American Academy of Periodontology; the July issue, 1931 and 1932, periodontal abstracts complete and indexed. This issue is of especial value to libraries. Subscription is $2 a year; address Journal of Periodontology, 555 W. Maple St., Birmingham, Mich.

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